**Before the**
**FEDERAL COMMUNICATIONS COMMISSION**
**Washington, D.C. 20554**

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| In the Matter of | ) | |
| | ) | |
| Globalstar, Inc. Petition for Notice of Inquiry | ) | RM-11808 |
| Regarding the Operation of Outdoor | ) | |
| U-NII-1 Devices in the 5 GHz Band | ) | |

# OPPOSITION OF NCTA – THE INTERNET & TELEVISION ASSOCIATION


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## I. INTRODUCTION AND SUMMARY

Globalstar petitions the Commission to fix a band that is not broken. Globalstar freely admits that its Mobile Satellite Service (MSS) system—which uses the 5096-5250 MHz band for feeder uplinks that support its duplex service—is not experiencing harmful interference today.[1] And as demonstrated in the attached technical analysis, submitted as the U.S. position to the last International Telecommunications Union (ITU) Working Party 5A meeting, Globalstar is unlikely to experience harmful interference from unlicensed devices in the future. Nonetheless, Globalstar asks that the Commission introduce significant new regulatory uncertainty for unlicensed users of the 5150-5250 MHz (U-NII-1) band and divert Commission resources to considering a petition that fails to allege any concrete harm. Globalstar's request is clearly unwarranted and improper.

Globalstar's filing devotes significant space to describing its "SPOT" MSS services,[2] but one-way SPOT and other simplex services make no use of the 5096-5250 MHz feeder-link spectrum where unlicensed devices operate. Only Globalstar's duplex (two-way voice, data, and messaging) services rely on feeder uplink spectrum in the 5096-5250 MHz band.[3] Whatever the merits of Globalstar's assertions about utilization of its SPOT and other simplex services, they are clearly inaccurate as they relate to the duplex services relevant here. According to

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[1] Globalstar, Inc. Petition for Notice of Inquiry Regarding the Operation of Outdoor U-NII-1 Devices in the 5 GHz Band, RM-11808, at 2 (filed May 21, 2018) (Petition).

[2] *See, e.g., id.* at 4.

[3] *See* Dirk Grunwald & Kenneth Baker, University of Colorado, & Rob Alderfer, CableLabs, *5 GHz U-NII-1: Wi-Fi and Globalstar Sharing Analysis*, at 5 (2014) (CU & CableLabs Paper) (appended to Letter from Rick Chessen, Senior VP Law and Regulatory Policy, NCTA to Julius Knapp, Chief of OET, FCC, ET Docket No. 13-49 (filed Jan. 22, 2014)).

Globalstar's Securities and Exchange Commission (SEC) filings, the company had only 69,033 subscribers *globally* of its duplex service at the end of March 2018.[4] Whether Globalstar's duplex subscribers experience any harmful interference from a particular noise increase in the band depends upon the capacity of Globalstar's system and how many subscribers use the service simultaneously.[5] With such low subscriber numbers, the Commission has every reason to view Globalstar's claims of future harmful interference with a healthy dose of skepticism, especially considering the 40 percent capacity increase Globalstar has touted for its second-generation satellites, even as its duplex subscriber base continues to shrink.[6] Add significant flaws in both Globalstar's noise floor measurement methodology and its system impact analysis, and the Commission should conclude that Globalstar's Petition merits no further consideration.

The technical merits of Globalstar's Petition only reinforce the conclusion that initiating a new proceeding would be unnecessary. Globalstar submits measurement data it claims show a 2 dB increase in the 5096-5250 MHz noise floor, beginning in February 2017 (*three years* after the Commission modified its rules for unlicensed operations in the U-NII-1) band. Globalstar's measurement methodology suffers from significant flaws that render these results unreliable at best, including measuring over a larger frequency range and geographic area than those where U.S. Wi-Fi devices operate. This imprecision makes it impossible to identify whether any measured noise is attributable to U.S. Wi-Fi operations, operations in adjacent spectrum, or even

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4 Globalstar Quarterly Report, FORM 10-Q, at 32 (May 10, 2018), https://www.globalstar.com/corporate/investors/sec-filings (GSAT 10-Q).

5 *See* Petition at Appendix B, Alan Wilson, et al., Roberson and Associates, LLC, *Analysis and Impact of Noise Rise on Feeder Uplinks of Globalstar Mobile Satellite Network*, at 3, 36 (May 21, 2018) (Roberson Analysis).

6 *See* Globalstar Annual Report, FORM 10-K, at 33 (Feb. 23, 2018), https://www.globalstar.com/corporate/investors/sec-filings (GSAT 10-K); GSAT 10-Q at 32.

transmissions originating outside the United States. Moreover, without additional measurements that vary in time and geography, the Commission lacks the data it would need to determine whether the measured noise increase reflects typical Wi-Fi deployments and usage patterns. Finally, because Globalstar's satellites can only measure noise in 1-2 dB increments at these power levels, and because it uses pre-launch test data as the basis for its noise floor reference—which would not account for ambient noise from the environment—its measurements of a 1-2 dB noise increase could significantly overstate the additional noise.

The capacity and power impact analysis by Roberson and Associates compounds the flaws of Globalstar's measurements. Far from confirming the accuracy of Globalstar's data, Roberson's analysis only aligns with Globalstar's results by making a series of highly unrealistic assumptions about outdoor Wi-Fi deployment rates, duty cycles, power levels, and other characteristics. Specifically, Roberson assumes that 10 percent of U-NII-1 access points (APs) operate outdoors—when deployment data from NCTA's members and other industry data suggests that number is approximately 1 percent—and that all those devices operate at high duty cycles, at the maximum 4 W EIRP permitted by the FCC's rules, without foliage clutter between such APs and the satellite. The Roberson Analysis also fails to reflect that Wi-Fi operations in U-NII-1 overlap only approximately half of Globalstar's CDMA channels, so it should have taken the important step of reducing the anticipated interference impact by half. Further, Roberson does not factor in Globalstar's subscribership or system capacity in evaluating whether a given noise increase would actually result in harmful interference to subscribers.

In the unlikely event that Globalstar someday experiences harmful interference from unlicensed operations in U-NII-1, the Commission's existing rules provide it sufficient redress. For example, it could contact the Office of Engineering and Technology (OET), which maintains a list of operators of more than 1,000 outdoor U-NII-1 APs and can assist Globalstar in identifying and remedying the issue. Or, as it acknowledges, Globalstar could "petition the Commission for immediate regulatory relief."[7] A further rulemaking on the U-NII-1 band simply is not necessary to ensure that Globalstar can continue to operate without harmful interference from unlicensed devices.

The Commission should find that the Petition plainly does not warrant further consideration and should dismiss it.[8]

## II. GLOBALSTAR'S PETITION IS PREMATURE AND DOES NOT WARRANT CONSIDERATION BY THE COMMISSION

### A. The Commission Cannot Reasonably Conclude that Globalstar Is Experiencing or Is Likely to Experience Harmful Interference from Wi-Fi

Globalstar is very careful not to say that its MSS service is experiencing harmful interference today. Instead, Globalstar says "it will suffer severe harmful interference in the future,"[9] and that if the Commission does not act on its speculative Petition today, Globalstar believes it will "lead to harmful interference to Globalstar operations" tomorrow.[10] The Commission therefore cannot reasonably conclude based Globalstar's Petition or its technical appendices that Globalstar is experiencing harmful interference today.[11]

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[7] Petition at 3.

[8] 47 C.F.R. § 1.401(e) ("Petitions which are moot, premature, repetitive, frivolous, or which plainly do not warrant consideration by the Commission may be denied or dismissed without prejudice to the petitioner."); *see also id.* § 1.430.

[9] Petition at 2.

[10] *Id.*

[11] The Commission also cannot reasonably conclude that failing to take up Globalstar's petition would lead to a violation of the U.S. treaty obligations. Globalstar claims in a cursory manner, citing only to ITU Resolution 229, that the Commission's failure to take "'corrective

Instead, Globalstar reasons that the Commission should issue a Notice of Inquiry (NOI) because Globalstar believes it *may* experience harmful interference from Wi-Fi devices in the future. It claims that its measurement data and the capacity impact analysis prepared by Roberson back up this speculative claim. But for the reasons described below, Globalstar's measurement data and analysis contain many flaws that render both unreliable, providing the Commission an insufficient basis to conclude that Globalstar's Petition warrants further consideration.

#### i. Globalstar's Measurements Overstate the Noise Rise and Fail to Demonstrate the Noise Increase Stems from Unlicensed Operations

Globalstar's measurement methodology suffers from significant flaws, with the result that the Commission lacks the information it would need to understand how much the noise has actually increased in the band since 2014 and whether any noise increase is attributable to U.S. Wi-Fi or other unlicensed operations or to another source.

***Globalstar measures over too large a frequency range and geographic area.*** Globalstar measured noise over the whole 5096-5250 MHz band where its feeder links operate, but Wi-Fi

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action' will lead to harmful interference to Globalstar operations not only within the United States, but also in other North and South American countries, all in violation of the Commission's obligations under the treaty-level ITU Radio Regulation, Resolution 229." Petition at 2-3, 17, 25. Although Resolution 229 restricts mobile stations in U-NII-1 to indoor use with transmit powers less than 200 mW, the Radio Regulations also specifically permit countries to authorize operations that do not conform to ITU Regulations, including Resolution 229, on a non-interference basis. *See* ITU Radio Regulation 4.4. The Commission's international obligations extend only to ensuring that non-conforming operations do not cause harmful interference. As discussed in further detail in Part II.C, below, the Commission already has rules in place to address any harmful interference to Globalstar's operations. Consequently, action on the Petition is in no way necessary in order to respect U.S. treaty obligations.

operates only in the 5170-5250 MHz portion of that band.[12] Any noise increase could have resulted from other services operating in the 5096-5150 MHz range.[13] Similarly, Globalstar measures at a point over the center of the United States where the satellite can see noise not just from the United States, but also from Canada, Mexico, and as far south as Northern Brazil.[14] Therefore, any noise increase could also have resulted from operations originating outside the United States.

***Globalstar's measurements do not account for the fact that Wi-Fi deployments vary in time and geography.*** Usage patterns for unlicensed devices are fairly well known. One would expect to see more extensive unlicensed operations during peak Internet usage hours (typically between 10:00 AM and 9:00 PM[15]), and to see more unlicensed activity in the 5 GHz band in urban and suburban population centers. Globalstar took measurements for only two minutes at a time a few times per month, all over the same, single point in the United States.[16] Without a longer measurement interval, conducted more frequently, it is impossible to know whether

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12 Petition at 5, 11.

13 According to a February 2017 NTIA report, for example, the Federal Government is testing Airport Network Location Equipment systems in the 5091-5150 MHz band at certain locations. Dep't of Commerce, Nat'l Telecomms. & Info. Admin., *5030-5250 MHz*, at 6 (Feb. 2017), https://www.ntia.doc.gov/files/ntia/publications/compendium/5030.00-5250.00_1Feb2017.pdf.

14 *See* Petition at Appendix A, *Globalstar 5 GHz Noise Floor Measurement Description and Current Results*, at 20 (May 21, 2018) (Globalstar Measurements).

15 *Sharing and Compatibility Study Between WAS/RLAN Applications and NGSO Systems in the Mobile Satellite Service with FSS Feeder Links Operating in the 5091-5250 MHz Band*, United States of American Contribution, Doc. No. 5A/727-E, at 23 (May 9, 2018) (attached to this Opposition as Appendix A).

16 Globalstar Measurements at 19.

Globalstar's few measurements truly represent a consistent rise in the noise floor. Moreover, without measurements over different points of the United States (and beyond its borders), which should reflect different noise levels in a balanced sampling of different geographic locations, the Commission cannot discern what might be causing the noise increase Globalstar claims to have measured. Despite requests to correct these important omissions after Globalstar submitted a study to the ITU, the company refused, other than to add an insufficient number of nighttime measurements.[17] Although Globalstar characterizes these measurements as revealing a "small decrease in the noise rise" at night,[18] Globalstar's raw results appear to reveal no consistent difference between day and night results.[19]

***Globalstar's initial noise floor baseline and its measurement resolution could result in significant overstatement of the measured noise.*** Globalstar does not clearly define how it obtained its reference noise floor for each satellite. It appears the baseline noise floor was based on pre-launch test data, which would not account for ambient noise from the environment before the 2014 introduction of outdoor Wi-Fi operations. The same problem would result if the reference noise floor measurements were based on "blue ocean" measurements, or flight test data from before 2014 (where the ambient noise would vary based on where the satellite was when the noise floor was measured).

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[17] *See id.* at 25.

[18] *Id.*

[19] *Id.* at A-7 through A-37.

Moreover, Globalstar claims that it is only capable of measuring noise at pre-defined threshold levels of approximately 1 dB.[20] Some satellites appear to be capable of measuring at only 2 dB resolutions at low signal levels.[21] If true, then an imprecise noise floor measurement could combine with any small increase in the noise floor and significantly skew the results.

Given the limitations of the Globalstar data, there is an insufficient basis for the Commission to conclude that the launch of a new rulemaking proceeding is warranted.

### ii. Globalstar's Technical Analysis Significantly Overstates the Potential Interference Impact of Wi-Fi Devices

Even if Globalstar's measurement data are accurate, the Roberson and Associates report appended to Globalstar's Petition fails to demonstrate that the 1-2 dB noise increase observed by Globalstar is currently causing harmful interference or is likely to cause harmful interference to Globalstar's system. First, the capacity impact analysis does not disclose that the impact of any inference will only be felt *if the satellite is operating near full channel or power capacity today*, which appears unlikely given Globalstar's subscribership levels. Second, the report assumes wildly unrealistic deployment numbers and operational parameters for Wi-Fi devices. Finally, the analysis also fails to discount the potential interference impact for operational realities, such as the fact that Wi-Fi operations overlap only half of Globalstar's channels.

***A reduction in capacity will only impact on Globalstar and its subscribers if Globalstar is operating near full channel or power capacity.*** The Roberson Analysis itself notes that "the

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[20] *Id.* at 16-17.

[21] *Id.* at 17-18 (disclosing "input power transfer data" only capable of distinguishing between power levels of -35.03, -33.04, and -31.99 dBm for M095-R at the power levels applicable here, and noting that the "1st detection resolution on M095-R and M097-R is 2 dB noise rise").

inherent CDMA co-channel and adjacent channel interference is directly related to the number of co-channel and adjacent channel users."[22] In other words, the interference levels already present in Globalstar's system before accounting for any additional Wi-Fi noise depend upon how many of Globalstar's end-users are using Globalstar's service simultaneously. Potential interference from Wi-Fi operations only becomes an issue if Globalstar is operating at a very high capacity today, with many subscribers operating at the same time.[23] Although Globalstar provides maps and statistics about its simplex SPOT service, which does not use U-NII-1, Globalstar has failed to provide basic and necessary information—such as subscribership and capacity—about the duplex service to which its interference claims might be relevant. Without such information, Globalstar's Petition is fatally deficient.

Publicly available information suggests that Globalstar's subscribership is small and decreasing and that its second-generation satellite system was purpose-built with expansive capacity. Globalstar's SEC filings indicate that the subscribership for its duplex service—the service that uses U-NII-1 for feeder links—has decreased in recent years. Globalstar reports 69,033 subscribers *globally* of its duplex service at the end of March 2018, down from 73,444 duplex subs in 2017[24] and 75,925 in 2016.[25] As CableLabs and researchers from the University of Colorado have pointed out, "a simple subscriber count implicitly overstates the actual usage of Globalstar's duplex system; most subscribers will generally use the service when out of range of

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[22] Roberson Analysis at 36.

[23] *See id.* at 3 (stating that degradation due to interference will be most acutely felt by Globalstar's users during periods of peak demand and high capacity usage).

[24] GSAT 10-Q at 32.

[25] GSAT 10-K at 33.

terrestrial communications, so simultaneous usage is likely to be much lower than total subscriber counts."[26]

Moreover, although Roberson uses the example of Globalstar's usage and capacity during Hurricane Katrina in 2005 to allege that Globalstar could experience high capacity demand during natural disasters,[27] they do not indicate whether this refers exclusively to Globalstar's duplex service, or whether the capacity estimate includes irrelevant simplex usage in a different band. Moreover, even assuming that this properly refers to only duplex traffic that uses the U-NII-1 band, this information refers to *different satellites* with dramatically lower capacity than those at issue here. Globalstar notes that, prior to 2014, it was unable "to offer commercially acceptable levels of Duplex service due to the degradation of our first-generation constellation,"[28] and, as a result, it launched a second generation of satellites beginning in 2010, five years after Hurricane Katrina. Globalstar says that it "improved the design of our second-generation constellation to last twice as long in space *and have 40% greater capacity compared to our first-generation constellation*."[29] Consequently, we know that Globalstar has increased its capacity by at least 40 percent since Hurricane Katrina, and that its subscriber numbers have been dropping.

***The Roberson Analysis assumes unrealistic Wi-Fi deployment numbers and operating parameters.*** Despite the availability of public information on real-world Wi-Fi deployment and operational parameters, Roberson assumes extensive outdoor Wi-Fi deployments inconsistent

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[26] CU & CableLabs Paper at 6 n.4.

[27] Roberson Analysis at 3, 45-46; *see also* Petition at 17.

[28] GSAT 10-K at 13.

[29] *Id.* (emphasis added).

with the experience of NCTA's members, and assumes that such operations have grown and will grow at an unreasonably fast pace. Roberson also incorrectly assumes that all outdoor Wi-Fi devices transmit at the maximum power levels, and that Wi-Fi devices transmit more often than they do. Specifically:

- Roberson concludes that one million Wi-Fi devices, or 10 percent of all U-NII-1 APs, must be operating outdoors today in U-NII-1 in order to cause the noise increase that Globalstar has measured.[30] But this is inconsistent with the informal data that NCTA collects from its members, which indicates that as of year-end 2017, a mere 1.13 percent of cable-deployed APs are located outdoors.[31] Other industry sources such as Dell'Oro Group also note outdoor deployments at or below 1 percent.[32] A more realistic but still conservative assumption would be 2 percent outdoor deployment. Moreover, to go from 1 dB degradation in February 2017 to 2 dB degradation in August 2017 would require an increase of 133% in the number of outdoor APs operating since the beginning of that seven-month period. This is also inconsistent with the data from the above sources. These discrepancies alone confirm that either Roberson's analysis or Globalstar's measurements (or both) are seriously flawed.

- Roberson assumes that all Wi-Fi devices transmit at the maximum allowed power of 4 W EIRP.[33] A real-world approach would consider the pool of potential devices capable of 4 W U-NII-1 operation, and analyze how many of those devices are actually likely to

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30 Roberson Analysis at 25-26.

31 *Working Document Towards a Preliminary Draft New Report ITU-R M.[RLAN REQ-PAR]*, United States of America Contribution, Doc. No. 5A-722-E, at 2 (May 8, 2018) (attached to this Opposition as Appendix B).

32 *See* Dell'Oro Group, *July 2017 Wireless LAN Report*, Figure 3-2 (2017) (for a publicly available reproduction of the relevant figure, see Letter from Paul Margie, Counsel to Apple Inc., Broadcom Corporation, Facebook, Inc., Hewlett Packard Enterprise, and Microsoft Corporation, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 17-183, at Attachment p. 14 (filed Jan. 26, 2018)).

33 Roberson Analysis at 17 & n.18. The analysis also does not account for the fact that Wi-Fi is time division duplex (TDD)-based with much lower EIRP for client devices that transmit around 50 percent of the time, or for the fact that a large percentage of outdoor deployments are related to medium density (e.g., municipal networks) and high density (e.g., sports arenas) operations that employ directional antennas and lower power to increase capacity and reduce co-channel and adjacent-channel self-interference.

operate at the maximum power level given different deployment scenarios, and how much of the time such high-power transmissions would take place.[34]

- Roberson assumes Wi-Fi duty cycles between 10 and 100 percent.[35] However, one study found that 99 percent of Wi-Fi access points operated at 10 percent duty cycle or less in a multichannel deployment such as available in the 5 GHz band.[36] Thus, a more real-world approach would have considered duty cycles of 10 percent or less. Because Roberson's analysis can only be made to align with Globalstar's measurements by assuming inaccurate Wi-Fi duty cycles, one or both must be flawed.

***The Roberson Analysis overstates the potential for interference by failing to discount for the real-world operational environment, including foliage clutter and limited Wi-Fi frequency range.*** Wi-Fi operates over only the 5170-5250 MHz portion of the band, overlapping only 53 of Globalstar's 104 CDMA channels in each polarity of Globalstar's feeder uplinks.[37] Any interference impact should be adjusted down by 49 percent to account for the fact that Wi-Fi operations only potentially impact approximately half of Globalstar's satellite communications channels.

In addition, most analyses assume some form of clutter loss to account for foliage and buildings that could obstruct the path between a transmitter and receiver.[38] Roberson's analysis

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[34] Compare Roberson's analysis assuming that devices operate at 4 W EIRP with Appendix B at 2-7, which calculates probability distributions for various power levels across user groups and deployment scenarios.

[35] Roberson Analysis at 27-32.

[36] Sanjit Biswas, et al., *Large-Scale Measurements of Wireless Network Behavior* (2015), http://conferences.sigcomm.org/sigcomm/2015/pdf/papers/p153.pdf.

[37] *See* Globalstar Measurements at 4 (showing in Figure 1 that Wi-Fi channels 36, 40, 44, and 48, operating in the 5170-5250 MHz range, overlap only approximately half of Globalstar's available CDMA channels).

[38] *See* Gregory Lapin et al., *Basic Principles for Assessing Compatibility of New Spectrum Allocations*, FCC Technological Advisory Council, Spectrum and Receiver Performance Working Group, at 29-30 (Dec. 2015), https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting121015/Principles-White-Paper-Release-1.1.pdf (stating that when modeling

does not appear fully to account for clutter loss.[39]

### B. The U.S. Contributions to ITU Working Party 5A on Wi-Fi/MSS Coexistence Demonstrate that Globalstar Is Very Unlikely to Experience Harmful Interference from Wi-Fi

The U.S. made a formal contribution in May 2018 to the preparatory process for the 2019 World Radiocommunications Conference that includes a study on coexistence between Wi-Fi devices and MSS feeder links in U-NII-1.[40] This study represents the consensus position of the U.S. government, and includes changes requested by government agencies and feedback received from other stakeholder participants in the U.S. Working Party 5A preparatory process (including Globalstar). Yet Globalstar ignores this study's realistic assumptions and fails even to reference it in its Petition.

Using reasonable, real-world assumptions about MSS operations and Wi-Fi deployment and operational parameters, the study finds that the maximum potential capacity loss to Globalstar's system is 0.025 percent (a loss of 0.256 percent over 9.68 percent of the service interval), while the maximum RF power loss is just 0.172 percent (a loss of 1.774 percent for 9.68 percent of the service interval).[41] This is well below the ITU recommendation that

aggregate interference to a satellite system, modeling "must account for . . . [t]he effect of ground clutter and terrain at the surface").

39 Globalstar Petition at 13 (noting that Roberson's analysis applies "a free-space path loss approach that also accounts for a building-shadowing factor"). Even where Roberson applies a building shadowing loss, it fails to do so for point-to-point links, stating that such links are "designed to propagate over paths free of any obstacles." Roberson Analysis at 18, 71. While that might be true for the path between point-to-point transmitter and receiver, it is not necessarily true of the path between terrestrial transmitter and satellite.

40 *See generally* Appendices A & B.

41 Appendix A at 38.

interference to MSS satellites should account for reduction in long term system capacity less than or equal to 1 percent.[42] Given that this capacity loss represents the impact on the maximum capacity of Globalstar's system, it is highly unlikely that this miniscule impact on Globalstar's maximum capacity would actually impact the delivery of service to its subscribers, who, as noted above, likely rely on only a fraction of the available capacity. In other words, the study concludes that "it is evident that allowing RLANs to operate both indoors and outdoors with higher powers in the 5 150-5 250 MHz [band under rules comparable to what the United States has in place] poses no harmful interference to the single operational MSS system, when sharing the band with the system's FSS feeder uplink."[43] NCTA has attached the full study, consisting of two U.S. ITU contributions, as Appendices A and B for the Commission's review and consideration.[44]

### C. The FCC's Existing Rules Provide Sufficient Protection Should Globalstar Experience Harmful Interference

Globalstar's Petition also does not merit consideration because the FCC's existing rules already provide adequate mechanisms for addressing any claims that unlicensed devices cause harmful interference to Globalstar's service.[45] Globalstar has not demonstrated that these existing avenues are insufficient to address its concerns.

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[42] Recommendation ITU-R S.1427 (2006).

[43] Appendix A at 39.

[44] Note that Appendix A is a compilation document—the relevant U.S. portion appears at pages 7-39. Appendix B is an analysis of the EIRP distributions resulting from a use case analysis based on implementation of U.S. U-NII-1 rules. Consistent with ITU practice, these documents include redline edits to prior ITU documents.

[45] Globalstar also argues that the Commission should take up its petition because the FCC's 2014 Order and rules did not specifically contemplate the potential for LTE-U and LAA

Specifically, Globalstar may contact OET's Laboratory Division directly to request that it look into the matter. Pursuant to 47 C.F.R. § 15.407(j), which the Commission adopted specifically in order to protect Globalstar's operations, the OET lab has contact information for every entity that has deployed more than 1,000 outdoor access points in U-NII-1. The letters submitted by operators acknowledge that "should harmful interference to licensed services in this band occur, they will be required to take corrective action . . . includ[ing] reducing power, turning off devices, changing frequency bands, and/or further reducing power radiated in the vertical direction."[46] The Commission found that this requirement provides it "a means to identify readily the largest deployments of U-NII access points, in the unlikely event the number of installations reaches a point where aggregate noise does cause harmful interference to Globalstar and we must take action to avoid such a result."[47] The Commission found that the antenna restriction, combined with the filing requirement for large U-NII-1 deployments "will

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deployments in U-NII-1. It argues that the FCC's rules for unlicensed APs "do not apply specifically to LTE-U/LAA base-station transmitters" operating in U-NII-1. Petition at 14-15; *see also* Roberson Analysis at 51-52. However, LTE-U/LAA devices, like other devices that transmit in unlicensed spectrum bands, must abide by the Commission's technical rules in order to obtain equipment certification. And FCC equipment authorization database records for LTE-U/LAA devices certified to operate in U-NII-1, including for outdoor APs, indicate that LTE-U/LAA equipment vendors consider themselves subject to the FCC's technical rules for Wi-Fi operations in U-NII-1, including the access point antenna restriction that limits RF energy above 30 degrees elevation. *See, e.g.*, Nokia Solutions & Networks equipment certification FCC ID 2AD8UAZRBRH1, FCC ID VBNAZRA-01. The filing requirement for operators of more than 1,000 outdoor APs applies equally to LTE-U/LAA deployments. Consequently, there is no ambiguity regarding the rules for LTE-U/LAA equipment operating in U-NII-1 that would require an NOI.

[46] 47 C.F.R. § 15.407(j).

[47] *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, First Report and Order, 29 FCC Rcd 4127, ¶ 38 (2014).

provide us with sufficient means for avoiding harmful interference *and addressing it if it does occur*."[48] Upon notification by the Commission that they are causing harmful interference to Globalstar's MSS system, Wi-Fi network operators must "cease operating the device upon notification by a Commission representative that the device is causing harmful interference," and may not resume operations "until the condition causing the harmful interference has been corrected."[49]

Before asking the Commission to begin a new rulemaking process with an NOI, Globalstar can and should contact the OET lab, which maintains the large operator filings, for assistance in resolving any harmful interference to its system. And as Globalstar itself notes, it also may avail itself of the ability to "petition the Commission for immediate regulatory relief from the harmful effects of unlicensed operations,"[50] if necessary. If the Commission finds harmful interference, it has the power at that time to resolve the issue. It is premature to consider Globalstar's Petition for NOI when Globalstar has neither availed itself of the remedies currently available to it, nor alleged that such remedies are insufficient. To NCTA's knowledge, no Wi-Fi operator has been asked to reduce or cease operations in U-NII-1 based on a complaint from Globalstar.

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[48] *Id.* (emphasis added).

[49] 47 C.F.R. § 15.5(c).

[50] Petition at 3.

## III. EXISTING USERS OF THE U-NII-1 BAND WOULD BE HARMED IF THE COMMISSION MOVES FORWARD WITH AN NOI

Moving forward with an NOI would create undesirable regulatory uncertainty that would harm American Wi-Fi consumers who rely on the U-NII-1 band today. The 5 GHz band has become a core Wi-Fi band in the United States. The 2.4 GHz band, once widely used for Wi-Fi operations, has become so congested that Apple and Cisco no longer recommend it for use in enterprise applications.[51] In the 5 GHz band, only U-NII-3 (5725-5850 MHz) and U-NII-1 offer the favorable technical rules that Wi-Fi devices require to flourish. In other portions of the 5 GHz band, Wi-Fi operations are limited by burdensome technical rules (called dynamic frequency selection, or DFS) designed to protect government radar operations. Consequently, these bands are not used as heavily for Wi-Fi, particularly in outdoor use cases.[52]

The latest Wi-Fi standards—IEEE 802.11ac, and the upcoming standard, IEEE 802.11ax—rely on very wide channel bandwidths of 80 and 160 MHz to bring the highest quality Wi-Fi experience to end users, enabling better streaming of video content and improving other high-bandwidth applications. Today, there is only one, non-contiguous 160 MHz channel available to American Wi-Fi consumers that is not burdened by DFS rules: 80 megahertz at U-NII-3 plus 80 megahertz at U-NII-1.

Since 2014 when the FCC adopted rule changes that facilitated more expansive Wi-Fi use of U-NII-1, the band has become a valuable part of the U.S. Wi-Fi ecosystem. The Commission should explore with caution any actions that could impair the Wi-Fi experience of American

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[51] *See* Cisco, *Enterprise Best Practices for iOS Devices on Cisco Wireless LAN*, at 4, 7 (Jan. 2018), https://www.cisco.com/c/dam/en/us/td/docs/wireless/controller/technotes/8-3/Enterprise_Best_Practices_for_Apple_Devices_on_Cisco_Wireless_LAN.pdf.

[52] Comments of NCTA – The Internet & Television Association, GN Docket No. 17-183, at 10-11 (filed Oct. 2, 2017).

consumers who currently use U-NII-1, or that could limit unlicensed use of the band in the future. Taking up Globalstar's Petition would make U-NII-1 an uncertain prospect for equipment makers and network operators planning future deployments. Even contemplating such drastic measures as returning to a prohibition on outdoor deployments or adopting an annual licensing requirement for unlicensed deployments[53] could depress interest and investment in U-NII-1.

## IV. CONCLUSION

For the foregoing reasons, Globalstar's Petition is insufficient from regulatory and technical perspectives. As described in detail above, Globalstar admits it is not experiencing harmful interference today. Globalstar's measurements fail to establish that unlicensed operations have caused the noise increase it claims to have measured. Additionally, its technical analysis fails to show that the projected noise increase would actually result in harmful interference to Globalstar's system in the future, when that system appears to operate with abundant capacity and limited subscribership. The Commission should not waste its resources and risk harming the unlicensed U-NII-1 ecosystem by moving forward with further consideration of Globalstar's legally insufficient and technically unsupported Petition.

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[53] *See* Petition at 24-25.

Respectfully submitted,

**/s/ Rick Chessen**

______________________________

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July 6, 2018

## **CERTIFICATE OF SERVICE**

I, Caitlin-Jean Juricic, hereby certify that on this 6th day of July, 2018, I served one copy of the foregoing Opposition by U.S. mail on the following party:

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# APPENDIX A

**(Consistent with ITU practice, this document includes redline edits to prior ITU documents)**

**Radiocommunication Study Groups**

Received: 8 May 2018

Reference: WRC-19 agenda item 1.16

**Document 5A/727-E**
**9 May 2018**
**English only**

**United States of America**

# SHARING AND COMPATIBILITY STUDY BETWEEN WAS/RLAN APPLICATIONS AND NGSO SYSTEMS IN THE MOBILE SATELLITE SERVICE WITH FSS FEEDER LINKS OPERATING IN THE 5091-5250 MHZ BAND

## 1 Introduction

Agenda item 1.16 invites the ITU-R to conduct sharing and compatibility studies in 5 150-5 250 MHz frequency band towards the possibility of enabling outdoor RLAN operations. The U.S. contributes revisions to this study, based on requests from other administrations to reflect what percentage of outdoor RLAN access points operating at 5 150-5 250 MHz band can be expected to operate outdoors and at higher power. Accordingly, this contribution takes into account views received at Working Party (WP) 5A's meeting in November 2017 that the study should reflect higher-power outdoor devices, such as those operating at 1 Watt, to facilitate broadband connectivity to the Internet.

## 2 Discussion

The 5 150 – 5 250 MHz band is allocated on a primary basis to the Fixed Satellite Service for the use of non-geostationary Mobile Satellite Systems feeder links. When Resolution **229 (Rev.WRC-12)** was first adopted, which provides for indoor use of RLANs in the band, several MSS operators were using or planned to use the band. In the last decade, use of RLANs to reach the Internet has grown tremendously and industry reports predicting growth have typically under-estimated the actual growth in RLAN use for broadband connectivity. As the U.S. did when it liberalized its rules for 5 150 – 5 250 MHz band over three years ago, Members of the ITU are encouraged to use radio frequency rationally, efficiently, and economically, and to bring new technologies to market as soon as viable.

The attached revisions to the preliminary draft new Report ITU-R M.[RLAN SHARING] assume that 2% of RLANs operating in the 5 150 – 5 250 MHz band are operating outdoors. Data from U.S. operators actually suggested the number was closer to 1% outdoor devices, but to be conservative, these revisions assume 2%. During the previous study cycle, JTG 4-5-6-7 proposed that for purposes of sharing studies, 5% of the devices should be modelled without building attenuation, but that alternatively administrations may choose to carry out a parametric analysis in any range between 2% and 10%. Accordingly, the U.S. revisions to the preliminary draft new Report ITU-R M.[RLAN SHARING] use 2% for outdoor devices with a parametric analysis.

Not only is this revision based on those lower outdoor figures, derived from U.S. industry study, but the U.S. accordingly proposes comparable revisions to Table 1B of the preliminary draft new Report ITU-R M.[RLAN REQ-PAR] (Document 5A/650, Annex 21). Table 1B of the preliminary draft new Report ITU-R M.[RLAN REQ-PAR] is provided as Table 3 in the attached revised study to Document 5A/650, Annex 23, preliminary draft new Report ITU-R M.[RLAN SHARING 5 150-5 250 MHZ]. More information on the data, sourcing, and analysis methodology is available in a separate input.

In response to requests from participants at the previous WP 5A meeting, the study also addresses the percentage of higher power outdoor devices, operating both at 1 Watt and 4 Watt, and conclude that the percentage of 4 Watt outdoor e.i.r.p. transmissions is calculated as 0.006% (directional) and 0.096% (omni) and the percentage of 1 watt outdoor e.i.r.p. transmissions is calculated at 0.035% (directional) and 0.024% (omni). The revised study also provides an e.i.r.p. distribution figure for indoor devices, per such requests, and concludes that the percentage of 4 Watt indoor e.i.r.p. transmissions is calculated as 13.0% (omni) and the percentage of 1 watt indoor e.i.r.p. transmissions is calculated at 11.7% (omni). The U.S. revisions also consider the interference impact on the sole MSS system's deliverable channel and RF power capacity, as recommended by Recommendation ITU-R M.1427. Recommendation ITU-R S.1427 recommends that interference to the MSS satellites should account for reduction in system capacity less than or equal to 1%. The revisions to the U.S. study demonstrate that maximum channel capacity lost is 0.025%, and the maximum radio frequency (RF) power capacity lost is 0.172% therefore conclude that 1% long-term impact is not exceeded.

## 3 Proposal

The United States proposes that WP 5A adopts the attached revisions to the sharing and compatibility study between WAS/RLAN applications operating in the 5 150-5 250 MHz band and Non-Geosynchronous Mobile Satellite Service with Fixed Satellite System Feeder Links operating in the 5 091 – 5 250 MHz band in conjunction with its studies under agenda item 1.16 (WRC-19) (5A/650, Annex 23).

**Radiocommunication Study Groups**

Source: Document 5A/TEMP/236(Rev.1)

**Annex 23 to**
**Document 5A/650-E**
**21~~20~~ May~~November~~ 2018~~7~~**
**English only**

## Annex 23 to Working Party 5A Chairman's Report

~~WORKING DOCUMENT TOWARDS A PRELIMINARY~~ DRAFT NEW REPORT ITU-R M.[RLAN SHARING 5150-5250 MHZ]

## Sharing and compatibility studies of WAS/RLAN in the 5 150-5 250 MHz frequency range

~~[*Editor's note: This document is a compilation of material presented in contributions submitted to May and November 2016, and the May and November 2017 WP 5A meetings (see Source Indication below) that the submitting administrations requested to be considered in developing this document. The content of this document need to be supported by corresponding sharing studies. The material contained in this document has not been agreed by WP 5A. The material if agreed could be used to satisfy the objective of agenda item 1.16.*]~~

*[**Editor's note:** Document 5A/554 is embedded below for reference.]*

R15-WP5A-C-0554!!
MSW-E.docx

## 1 Introduction

This Report includes the sharing and compatibilities studies of WAS/RLAN in the 5 150-5 250 MHz frequency range.

It is intended to represent the response to a part of *invites ITU-R c)* "to perform sharing and compatibility studies between WAS/RLAN applications and incumbent services in the frequency band 5 150-5 350 MHz with the possibility of enabling outdoor WAS/RLAN operations including possible associated conditions" of Resolution **239 (WRC-15)** under WRC-19 agenda item 1.16.

# 3 Overall view of allocations in the 5 150-5 250 MHz range

| Allocation to services | | | Expected studies |
|---|---|---|---|
| **Region 1** | **Region 2** | **Region 3** | |
| **5 150-5 250** | FIXED-SATELLITE (Earth-to-space) 5.447A<br>MOBILE except aeronautical mobile 5.446A 5.446B<br>AERONAUTICAL RADIONAVIGATION<br>5.446 5.446C 5.447 5.447B 5.447C | | Coexistence between WAS/RLAN outdoor operations and FSS (feederlinks for non-GSO) and Aeronautical Radionavigation |

# 4 Assumptions on technical and operational elements for the sharing and compatibility of WAS/RLAN with other services

## 4.1 Technical and operational characteristics of the WAS/RLAN operating in the 5 150- 5 250 MHz ranges

*[**Editor's note:** The text below needs to be modified after finalization of the document Report ITU-R M.[RLAN REQ-PAR].]*

[Option 1

*[RUS 5A/196]*

Technical and operational characteristics of RLANs are presented in Recommendation ITU-R M.1450 «Characteristics of broadband radio local area networks». In Canada, the e.i.r.p. of RLANs operating in the frequency band 5 150-5 250 MHz is 250 mW conducted (-6 dBW). In the U.S., the e.i.r.p. of RLANs operating in the frequency band 5 150-5 250 MHz is 1 000 mW conducted (0 dBW), however outdoor operations with antenna elevation angles in excess of 30 degrees from the horizon must not exceed 125 mW e.i.r.p., and all WAS/RLAN emissions outside of that band must be below -27 dBm/MHz. At the same time RLANs operating in the territory of Europe, and in numerous Region 3 countries including Australia, are restricted to an e.i.r.p. of 200 mW (-7 dBW) in the frequency bands 5 150-5 250 MHz and indoor only operation.

e.i.r.p. spectral densities specified in Recommendation ITU-R M.1450 shows that it addresses RLANs having carrier bandwidth of 20 MHz. However taking in account the achievements in RLANs development such as IEEE standard 802.11ac, the considered Report includes analysis of networks having carrier bandwidth of both 20 MHz and 160 MHz.

*[UK and ESA 5A/246, 96]*

Option 2

### 4.1.1 Characteristics of RLAN in 5 150-5 250 MHz Band

## 4.2 Technical and operational characteristics of FSS links used for MSS feeder links in the 5 150-5 250 MHz

*[Globalstar 5A/395]*

The parameters of the feeder uplinks of the HIBLEO-X MSS system are summarized in the Table below.

TABLE 2

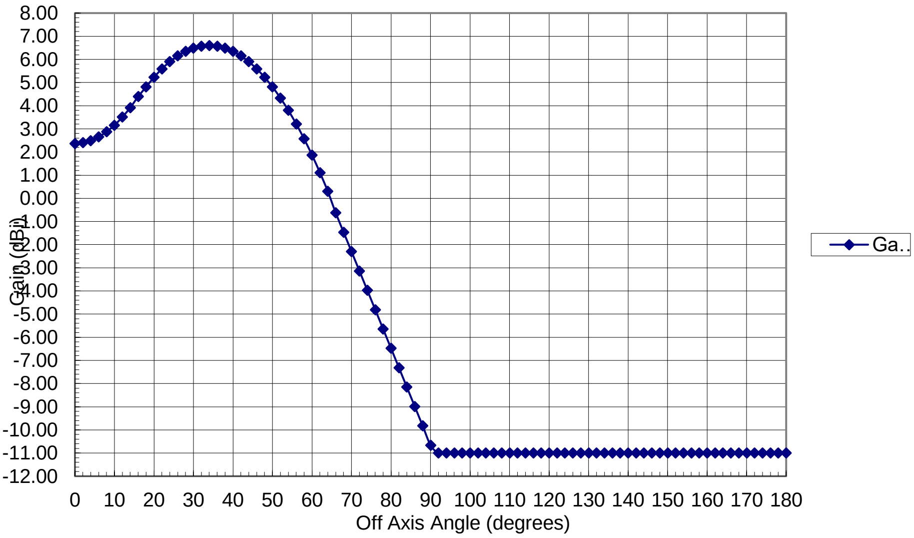
**MSS Feeder Link Parameters**

| Parameter | HIBLEO-X |
|---|---|
| Satellite orbit altitude *h* (km) | 1 414 |
| Satellite Inclination (degrees) | 52 |
| Frequency Range (MHz) | 5 091-5 250 |
| Satellite receiver bandwidth *B* (MHz) | 1.23, 16.5, 19.38 |
| I/N (dB) for time invariant sources of interference | -12.2 |
| I/N (dB) for time variant sources of interference | For further study |
| Satellite receiver noise temperature *T* (K) | 550 |
| Polarization discrimination $L_p$ (dB) | 1.4 |

The spacecraft receive antenna is an “iso-flux” antenna and the gain pattern is shown below.

FIGURE 3

**Spacecraft Receive Antenna Pattern**




## 4.3 Technical and operational characteristics of the Aeronautical Radionavigation service operating in the 5 150-5 250 MHz

*[**Editor’s note:** Parameters below need confirmation from WP 5B.]*

*[RUS 5A/397]*

In accordance with Recommendation ITU-R M.2007, ARNS systems operate in the frequency band 5 150−5 250 MHz all over the world. In compliance with *recommends 1* Recommendation ITU-R M. 2007 that the technical and operational characteristics of the radars operating in the ARNS described in Annex 1 should be considered representative of those operating in the frequency band 5 150-5 250 MHz and used in studies of compatibility with systems in other services. Table 1 below provides the technical parameters of airborne sense and avoid systems to be used for consequence assessment of outdoor WAS/RLAN usage.

TABLE 1

**Technical parameters of aircraft based sense and avoid radar**

| **Parameter** | **Radar No. 1** |
|---|---|
| Platform height (km) | Up to 20 |
| Radar type | Air to air traffic collision avoidance system |
| The range of measured ground speed (km/h) | Up to 1 500 |
| Frequency tuning range (MHz) | 5 150-5 250 |
| Emission type | Linear FM (LFM) pulse |
| LFM chirp bandwidth (MHz) | 20 |
| Pulse rise and fall times (μs) | 0.1-0.2 |
| RF emission bandwidth –3 dB<br>–20 dB (MHz)<br>–40 dB | 18<br>22<br>26 |
| Receiver IF –3 dB bandwidth (MHz) | 30 |
| Receiver noise figure (dB) | 5 |
| Antenna gain (dBi) | 33-36 |
| First antenna side lobe (dBi) | 18-20 |
| Horizontal beamwidth (degrees) | 8 |
| Vertical beamwidth (degrees) | 8 |
| Polarization | Vertical |
| Vertical antenna scan (degrees) | ±45 |
| Horizontal antenna scan (degrees) | ±45 |
| Protection criteria (dB) | −6 |

### 4.4 Technical and operational characteristics of aeronautical mobile service systems limited to aircraft transmissions of aeronautical mobile telemetry (AMT) for flight testing in the frequency ranges 5 150-5 160 MHz

*[**Editor's note:** Parameters below need confirmation from WP 5B.]*

The following table provides the aeronautical mobile telemetry transmitting and receiving stations characteristics relevant for p~~r~~erforming sharing analysis with other services in co-frequency.

TABLE 1

**Aeronautical mobile telemetry characteristics**

| | | |
|---|---|---|
| **Transmitter (onboard aircraft)** | | |
| Frequency range | MHz | 5 091-5 160 |
| Channel bandwidth | MHz | 8 |
| Modulation | | Single Carrier-SOQPSK or COFDM-QPSK |
| Maximum transmit power [1] | dBW | 20 |
| Aircraft antennas location | | One antenna on the bottom of the aircraft and another antenna on the top of the aircraft |
| Tx antenna gain | dBi | 0 |
| Cable loss | dB | 2 |
| Aircraft altitude | m | 0 – 15 000 |
| Aircraft deployment | | Typical: 3 Aircraft in flight at the same time but not co-frequency (each aircraft use different channels)<br>Maximum: 5 Aircraft in flight at the same time but not co-frequency (each aircraft use different channels) |
| **Receiver (on ground)** | | |
| Antenna pattern | | Steering Parabolic antenna<br>Recommendation ITU-R S 580-6 |
| Receiver antenna gain | dBi | 40 |
| Receiver noise temperature | K | 310 |
| Receiver altitude from ground level | m | Between 6 and 40 |
| Receiver antenna elevation range | ° | Between -5 and 90 (99% of time the elevation is between -2° and 5°) |
| Protection criteria I/N | dB | -6 |
| [1] The effective power is adjusted to comply with the pfd limits defined in Annex 1 of Resolution **418 (Rev.WRC-15)**. | | |

# 5 Sharing studies per service

## 5.1 Sharing and compatibility of MSS feeder links ~~versus~~ and WAS/RLANs in the 5 150-5 250 MHz band

~~*[Editor's note: Further discussions and potential future input contributions are invited to improve the text below extracted from Documents 5A/381 and 5A/404]*~~

*[AUS 5A/81]*

The current, worldwide sharing rules, in the lower 5 150-5 250 MHz band, to protect co-band non-GSO MSS E-to-s feeder links, appear in Resolution **229 (Rev.WRC-12)** which, inter alia, requires individual WAS/RLAN transmitters to ***"be restricted to indoor use with a maximum mean e.i.r.p. of 200 mW and a maximum mean e.i.r.p. density of 10 mW/MHz in any 1 MHz band or equivalently 0.25 mW/25 kHz in any 25 kHz band"***.

Further background on the development of Resolution **229 (Rev.WRC-12)**, together with information on related ITU-R Recommendations, can be found in Document 5A/81 from Australia.

Field Code Changed

Field Code Changed

Importantly, Resolution **229 (Rev.WRC-12)** assumes that only 1% of RLAN deployments would operate outdoors and that the aggregate noise from WAS/RLANs into victim non-GSO MSS E-to-s feeder link satellite receivers would likely come from multiple countries.

*[USA 5A/381]*

The Resolution **229 (WRC-12)** indoor use restriction on WAS/RLAN transmitters was based on the assumption that many different MSS companies would share the 5 150-5 250 MHz band, whereas today there is only one satellite operator that operates feeder link stations in the 5 096-5 250 MHz band.

~~*[Editor's note: Studies supporting the text below have not been received yet.]*~~

~~[~~Studies conducted by one administration concluded that the noise floor increase seen by the satellite will be a function of the aggregated energy from WAS/RLAN emissions at elevation angles above 30 degrees. By applying technological measures to operations above this elevation angle, the energy that will be received by the satellite from each individual access point would be sharply reduced, resulting in reduced aggregate noise at the satellite. As a result, it is far less likely that harmful interference will occur, even with proliferation of access points greater than that originally presumed.

Permitting fixed access point outdoor operations at a conducted power level of up to 1 W (30 dBm), and a PSD of 17 dBm/MHz with an allowance for a 6 dBi antenna gain (*i.e.* a total 36 dBm e.i.r.p.), and limiting the maximum e.i.r.p. above 30 degrees elevation to 125 mW (21 dBm) e.i.r.p., provides reasonable protection from harmful interference to the MSS system.~~ ]~~

Expressing this limit in terms of e.i.r.p. provides flexibility regarding how to design WAS/RLAN equipment, while still achieving the required levels of protection. WAS/RLAN manufacturers will be able to demonstrate compliance with the e.i.r.p. limit by reducing antenna gain in the upward direction, or by limiting the transmitter power, or a combination of the two, as best suits their particular purpose. Additionally, the national authority implemented a reporting requirement on any widespread deployments of outdoor access points and required WAS/RLAN operators to take corrective action in the event of any claims of harmful interference, to include reducing power, turning off devices, changing frequency bands, and/or further reducing power in the vertical direction. To date, none such claims of interference have been made. The power limits above 30 degrees described above for individual devices, combined with the filing requirement for deployments of large numbers of devices will provide a sufficient means for avoiding harmful interference and addressing it if it does occur. It is important to note that while in-band WAS/RLAN emissions were increased, emissions outside that band were maintained at a level of -27 dBm/MHz.

*[AUS 5A/404]*

In its Document 5A/404 contribution, one administration (as a major operator of LEO-D, non-GSO MSS feeder uplinks in the 5 150-5 250 MHz band) raised concerns with the Doc. 5A/210, as has now been now been reflected in the above text. This administration provided the following Tables to compare the domestic rules described in Document 5A/210 for RLANs in this frequency band and the mandatory requirements of Resolution **229 (Rev.WRC-12).**

Table 1 provides a comparison of the US and Resolution **229 (Rev.WRC-12)** rules for RLAN emission elevation angles less than or equal to $30^0$ and Table 2 for RLAN emission elevation angles greater than $30^0$ elevation.

TABLE 1

**RLAN emission elevation angles between $0^0$ and $30^0$**

| Parameter | Resolution **229 (Rev.WRC-12)** | USA | Difference |
|---|---|---|---|
| Maximum e.i.r.p. | 200 mW (23 dBm) | 4 W (36 dBm) | 13 dB |
| Location constraint | Yes, indoor only | No, outdoor permitted | |
| Resultant max. outdoor e.i.r.p. | 6 dBm* | 36 dBm | 30 dB* |

* Assumes building loss of 17 dB.

TABLE 2

**RLAN emission elevation angles >$30^0$**

| Parameter | Resolution **229 (Rev.WRC-12)** | USA | Difference |
|---|---|---|---|
| Maximum e.i.r.p. | 200 mW (23 dBm) | 125 mW (21 dBm) | -2 dB |
| Location constraint | Yes, indoor only | No, outdoor permitted | |
| Resultant max. outdoor e.i.r.p. | 6 dBm* | 21 dBm | +15 dB* |

* Assumes building loss of 17 dB.

*[**Editor's note:** These are views from administrations rather than technical material.]*

One administration noted that the domestic rules described in Document 5A/210 that apply to RLANs in the 5 150-5 250 MHz frequency band potentially result in up to 30 dB (i.e. 1,000 times) more radiated power for RLAN emission elevation angles ≤$30^0$ and up to 15 dB more radiated power for elevation angles >$30^0$ when compared with that prescribed in Resolution **229 (Rev.WRC-12)**.

~~[One administration also noted that the Document 5A/210 had not provided any technical, operational, sharing or compatibility studies to support the e.i.r.p. increase or for removing the indoor only requirement. Further, the choice of a 30⁰ elevation angle breakpoint for maximum e.i.r.p. was not supported by reference to any studies and was inconsistent with the operation of the Australian LEO-D feeder uplinks which carry commercial traffic from 10⁰ to the opposite 10⁰ in elevation.~~

~~This administration asked the contributor of Document 5A/210 to advise WP 5A how the 30⁰ elevation angle was chosen and to provide an analysis of the aggregate noise that would be received by LEO-D as a result of RLANs operating outdoors at the 21 dBm e.i.r.p. level (and also at the 36 dBm e.i.r.p. level). ]~~

### 5.1.1 Study 1 (USA 5A/534)

#### 5.1.1.2 Sharing Cases

~~[Editor's Note: Beamforming was not used in this simulation, but future studies may be available to take account of such technologies.]~~

Actual real-world system interactions and impacts are often not available when considering new allocations or where conditions of use are concerned. Often, only simplified, assumption-driven analyses outlining worst case interference risks are provided. A better technical understanding of risks is crucial when attempting to expand access for new uses. Consistent with Res. **239**, we must also consider further new developments in RLAN technologies, such as beam forming that will allow for lower transmit power and provide higher directivity, improving the interference condition over time.

Consistent with Res. **239 (WRC-15)**, this study attempts to provide as accurate and realistic analysis on the impact of band sharing between RLANs and MSS given our present understanding of all parameters, as described in this document, assuming RLANs parameters in Table 1A in Annex 27 of W P5A Chairman's Report (Document 5A/469).

There are two cases of possible interference that could result when RLANs and FSS feeder links operate simultaneously in the 5 150-5 250 MHz band.

#### 5.1.1.2.1 Aggregate RLAN Transmitters-to-FSS Feeder Uplink of MSS Satellite System

In the first case we will undertake a sharing analysis to ascertain the impact of incidental Earth-to-space transmissions of the aggregate of RLAN devices operating within line of sight of the FSS feeder antenna.

#### 5.1.1.2.2 MSS Gateway Transmitter-to-RLAN Receiver

It might also be appropriate to examine interference by MSS gateway transmitters to RLAN receivers. However, while this form of interference may be possible, the number of these gateways is very small. It is possible to establish exclusion zones utilizing standard procedures around the small number of gateways, since they are fixed. This, however, is not the focus of this study and will not be treated further.

### 5.1.1.3 Technical Characteristics

The following sections summarize the FSS/MSS and RLAN parameters as considered in this study.

#### 5.1.1.3.1 Characteristics of MSS System

This contribution will focus on the study of the MSS system referred to as LEO-D in a number of ITU-R Recommendations and Reports. The system consists of 34 active[1] spacecraft at an altitude of 1 414 kilometers and an inclination angle of the orbits of 52 degrees, with respect to the Equator. The spacecraft antenna has a full Earth-coverage beam with an approximate radius of 2 900 kilometers (0 dBi contour) on the surface of the Earth.

This system can be characterized as a "bent-pipe satellite system" (see Figure 1). In the forward path the feeder uplink uses the C-band between the gateway and the satellites to transmit eight 16.5 MHz channels on each right hand and left hand circular polarizations. The sixteen channels are received at the satellite transponder, converted to S-band and each mapped to one of sixteen downlink service beams. Within each of the beams, there are thirteen 1.23 MHz frequency division multiplexed (FDM) carrier channels. Each 1.23 MHz carrier employs code division multiple access (CDMA) to provide multiple voice or data circuits to user terminals. The return path is provided in a similar manner with L-band employed on the service uplink and C-band on the feeder downlink; however, RLANs operating in the 5 150-5 250 MHz band overlap the C-band frequencies utilized in the forward path and thus are the focus of this analysis.

Additional MSS system characteristics as provided throughout this document are taken from several sources and noted.

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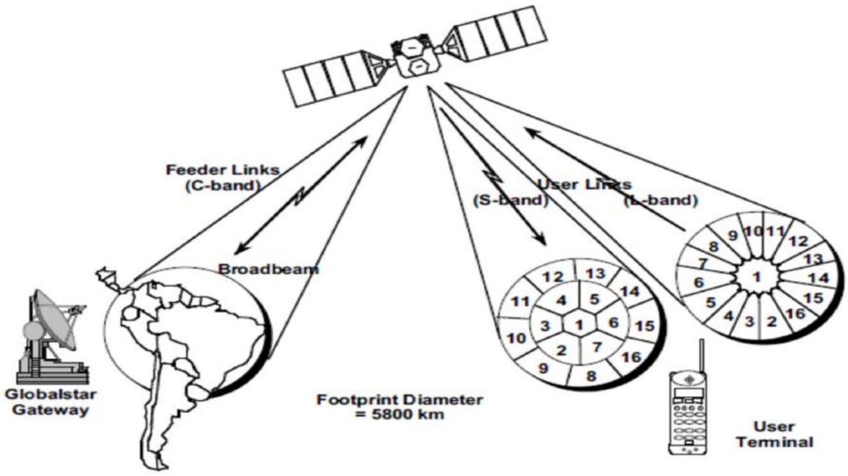
[1] https://celestrak.com/satcat/search.asp.

FIGURE 1

**Single MSS satellite system with Feeder Links at 5.1-5.2 GHz**




Most recent parameter values of the MSS satellite system under study were extracted from an MSS study included in WP 5A Document 5A/395 or other sources[2], and are summarized in the Table 1 and Figure 2.

TABLE ~~2~~1

**Feeder Up-link Parameters**

| Parameter Discription | Values | Comments |
|---|---|---|
| Satellite orbit altitude (km) | 1 414 | WP5A document 395 |
| Satellite Inclination (degrees) | 52 deg | WP5A document 395 |
| Frequency Range studied (MHz) | 5 150-5 250 MHz | Per Resolution 239 |
| Left and Right Circular Polarized | LHCP & RHCP | Globalstar, GS-TR-94-0001 |
| CDMA carrier channel bandwidth | 1.23 MHz | WP5A document 395 |
| Satellite receiver noise temperature *T* (K) | 550.0 K | WP5A document 395 |
| kTB Noise Satellite | -140.3 dBW | Calculated |
| I/N (dB) Protection threshold | TBD | Used -12.2 dB per ITU-R S.1432-1 |
| Polarization discrimination | 1.4 dB | ITU RR Appendix 8 (2.2.3) |
| Receive antenna pattern see figure below. | Fig 2 | WP5A doc 395 & ITU-R M.1454-0 |

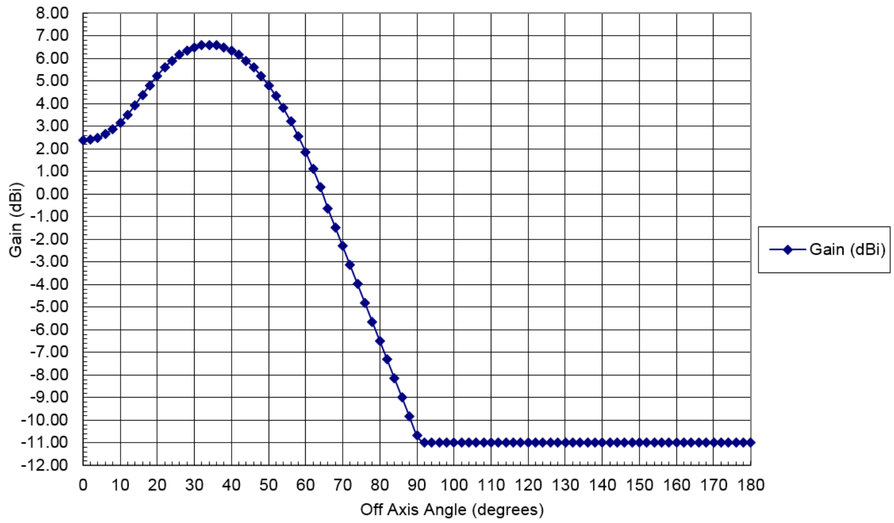
For the purposes of this study, the -12.2 dB value was used for comparison reasons only. The I/N protection value for the FSS feeder link applicable to time variant source of interference such as RLANs is still under consideration by WP 4A.

The spacecraft receive antenna is an “iso-flux” antenna, and the gain pattern is shown below.

[2] Globalstar, L.P., “Description of the Globalstar System”, GS-TR-94-0001Revision E, December 07, 2000.

FIGURE 2

**Spacecraft receive antenna pattern (feeder loss included)**




#### 5.1.1.3.2 Characteristics of RLANs

This study assumes that interference from WAS/RLAN would be primarily from RLAN TDD transmissions originating from RLAN cells defined by serving access points (APs). The RLAN parameters given below are based upon this assumption. As there are potentially millions of RLAN APs in the 5 150-5 250 MHz band, it is impractical to simulate each RLAN cell as an individual interferer. Hence, the power from the individual cells has been aggregated as an input to the satellite receiver. ~~In order to accurately calculate the aggregate power contributed by the multitude of RLANs within the large coverage footprint of the FSS feeder antenna for each MSS satellite,~~To perform this aggregation the area is subdivided into grids so that factors such as antenna discriminations, path loss, busy hour, clutter loss,~~ and~~ building entrance loss and operational characteristics can be accounted for in a reasonably high resolution manner and accurately reflect the each interference contribution. ~~thereby accurately representing the link interference contribution.~~ To this end the Oak Ridge National Laboratory's (ORNL) LandScan™ provides 30" X 30" grid resolution (approximately 1 $km^2$) global population distribution data.[3] In order to have a more manageable number of population centers and compute the area associated with a given population sample, granularity of this data was reduced. The grids associated with the new population centers vary in size from 14 $km^2$ to 50 $km^2$ and results in a grid count of 278,248. Characteristic location and population data for each grid is utilized to compute its RLAN interference contribution to the FSS feeder link.

For the purpose of applying representative parameters the analysis categorizes each grid as one of three demographics: urban, suburban, and rural based on population density of the grid. ~~During the JTG one administration proposed a distribution of populations over a defined area for the three~~

3 http://web.ornl.gov/sci/landscan/landscan_documentation.shtml.

~~demographics~~[4]~~.~~ An investigation of densities that would best give an indication of demographic behavior was used. A survey[5] of resident's perception of where they lived provides the most realistic results. Using this information we define grids in the following manner:

– Rural, for grids with population density less than or equal to ~~495~~ 40 people/km$^2$;

– Suburban, for grids with population density greater than ~~495~~ 40 but less than or equal to ~~4 177~~824 people/km$^2$;

– Urban, for grids with population density greater than ~~4 177~~824 people/km$^2$.

Each demographic is further defined by its makeup of user types. Three user groups with different operational characteristics are assumed for use in this study: Corporate, Public Access, and Residential. The actual population for each demographic is determined, during the simulation, by calculating densities of each grid and assigning its population to the appropriate demographic based on the densities defined above. However, for the purpose of helping to properly allocate characteristics to each demographic, an estimate was made from the U.S. census bureau's 2010 ZIP Code Tabulation Areas. The result is 39.9%, 45.2% and 14.9% for urban, suburban and rural populations respectively. In its annual report iPass, a wireless Internet service provider, claims to have the largest Wi-Fi network in the world and through its cloud based network management system it regularly collects data through auto discovery and hotspot rating to create a picture6 of AP deployment on a global, regional and country wide basis. Utilizing the demographic information along with AP distributions by user group, AP distributions for each user group across the demographics may conservatively be estimated. The results are provided in Table 2 and are used to develop demographic specific, busy hour, market, system and activity factors, and antenna height probabilities.

TABLE 2

**Access Point Distributions**

| Type | Urban | Suburban | Rural | Total |
|---|---|---|---|---|
| Demograhic Pops % | 39.9% | 45.2% | 14.9% | 100% |
| Corporate % | 5.0% | 3.4% | 0.2% | 3.6% |
| Public Access % | 2.8% | 2.1% | 0.6% | 2.1% |
| Residential % | 92.1% | 94.5% | 99.3% | 94.3% |

~~For this analysis the study assumes that interference from WAS/RLAN would be primarily from RLANs and more specifically from access points (AP) in RLAN systems. The RLAN parameters given below are based upon this assumption. As there are potentially millions of RLAN access points in the 5 150-5 250 MHz band, it is impractical to simulate each access point as an individual interferer. Hence, the power from the individual access points has been aggregated as an input to the satellite receiver.~~

[4] ~~See R12 JTG 4567-C-0584.~~

[5] https://fivethirtyeight.com/features/how-suburban-are-big-american-cities/.

[6] http://www.ipass.com/wifi-growth-map/.

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### 5.1.1.3.2.1 RLAN e.i.r.p level distributions

~~Table 2 provides a summary of e.i.r.p. level distributions from R15-WP5A-C-0469, Annex 27, M.[RLAN REQ-PAR] Table 1a. The e.i.r.p level distributions were developed for RLANs operating in the 5 725-5 850 MHz band in both indoor and outdoor environments.~~

Previous ITU contributions provided information characterizing the RLAN e.i.r.p. environment. A summary of e.i.r.p. level distributions is included in Document 5A/469 (Annex 27), M.[RLAN REQ-PAR] Table 1a. The e.i.r.p level distributions were developed for RLANs operating in the 5725-5850 MHz band in both indoor and outdoor environments.

Table 1b[7] provides e.i.r.p. level distributions for the 5150-5250 MHz band at both 1 watt and 4 watt levels.

Table 3 reflects these new e.i.r.p. distributions updating Table 1b of Document 5A/650 (Annex 21), preliminary draft new Report ITU-R M.[RLAN REQ-PAR]. These are the values applied to grid RLAN device counts to so that the appropriate e.i.r.p. and accompanying losses are applied when calculating aggregate interference to the satellite system.

~~reference as well as a information provided by an RKF Engineering Solutions study downstream to upstream transmission rate occurwireless services providers percentage of outdoor devices were based on years 2014 through 2017. In order to take into account growth, we consider the percentage of aggregate outdoor devices delivered from 2014 thru 2017 versus those delivered from 2014 through 2021. The ratio of the latter to the former is 1.38, so we adjusted all 1 watt and 4 watt omni and directional (point-to-point) percentages upward by this ratio. I[8];,Percentage of devices in each environment was calculated to be 94.7% and 5.3% for indoor and outdoor respectively (see Table 2). These are the values applied to grid RLAN device counts to so that the appropriate e.i.r.p. and accompanying losses are applied when calculating aggregate interference to the satellite system.~~

TABLE ~~2~~3

**RLAN e.i.r.p level distributions**

| Type | 4 W (directional) | 4 W (omni) | 1 W (directional) | 1 W (omni) | 200 mW (omni) | 80 mW (omni) | 50 mW (omni) | 25 mW (omni) | Total % | Wgt Avg EIRP |
|---|---|---|---|---|---|---|---|---|---|---|
| Indoor | 34.7 dBm | 34.7 dBm | 28.6 dBm | 28.6 dBm | 23 dBm | 19 dBm | 17 dBm | 14 dBm | | |
| E.I.R.P.s | 2965 mW | 2965 mW | 724 mW | 724 mW | 200 mW | 80 mW | 50 mW | 25 mW | | |
| Indoor % | 0.0% | 13.0% | 0.0% | 11.7% | 14% | 19.82% | 10.99% | 28.56% | 98.00% | 27.3 dBm |
| Outdoor | 33.1 dBm | 33.1 dBm | 30 dBm | 30 dBm | 23 dBm | 19 dBm | 17 dBm | 14 dBm | | |
| E.I.R.P.s | 2051 mW | 2051 mW | 1000 mW | 1000 mW | 200 mW | 80 mW | 50 mW | 25 mW | | |
| Outdoor % | 0.006% | 0.096% | 0.035% | 0.024% | 0.35% | 0.50% | 0.28% | 0.72% | 2.00% | 23.1 dBm |

| Tx power | 1 W (directional) | 1 W (omni) | 200 mW (omni) | 80 mW (omni) | 50 mW (omni) | 25 mW (omni) | Total % | Wgt Avg EIRP |
|---|---|---|---|---|---|---|---|---|
| Tx power | 1000 mW | 1000 mW | 200 mW | 80 mW | 50 mW | 25 mW | | |
| Indoor % | 0% | 0% | 18% | 25.60% | 14.20% | 36.90% | 94.70% | 18.9 dBm |
| Outdoor % | 0.10% | 0.20% | 0.95% | 1.35% | 0.75% | 1.95% | 5.30% | 21.1 dBm |
| | | | | | | | Both Indoor and Outdoor | 19.0 dBm |

[7] See R15-WP5A-C-0650, Annex 21, M.[RLAN REQ-PAR]

~~[8] SMALL CELL FORUM RELEASE 10.0 scf,, DOCUMENT 050.10.02, "Small cells market status report", February 2018, Figure 3-1, https://scf.io/en/documents/050_-_Small_cells_market_status_report_February_2018.php~~

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#### 5.1.1.3.2.2 RLAN antenna discrimination

As has been previously noted[9], when considering the RLAN antenna discrimination to be used in the sharing studies, the following factors should be considered:

– For simplification, only AP ~~emissions~~ counts are considered in the technical studies, but it is recognized that this is based on the fact that either the AP or the client terminal is transmitting. Therefore, in order to accurately represent this condition, a composite of AP and terminal antennas would normally be ~~is~~ employed is used.

– In addition, when considering the discrimination of the AP antennas~~,~~ positioning~~-~~ needs to be considered~~.~~ within the corporate, public access and residential environments. Indoor residential APs are almost always located on a surface. Indoor corporate and public access locations can vary considerably and include office buildings, hotels, auditoriums, arenas, fast food hotspots, etc. A~~a~~ntennas are often~~may be~~ located on the ceiling facing downward, or in other instances on the wall facing horizontal or tilted downward or on ~~a desk~~some surface. ~~facing upward~~. Outdoor AP antennas may be pole mounted, strand mounted or wall mounted and are generally always with the main beam facing or tilted downward ~~and likewise may face up, down or horizontal~~ to provide the desired coverage. ~~A composite discrimination value in the direction of the satellite is assumed, based on the patterns resulting from the various antenna placements.~~

– While client terminal antennas may have some gain greater than zero, it is impossible to determine which direction they are facing during each transmission, so for simplicity's sake it is assumed that over time they appear omnidirectional with 0 dBi gain. However, terminal antennas are likely to be blocked by the user from the satellite approximately 50% of the time. A proposed value for body loss of 4 dB is provided in Table 4 of Report ITU-R M.2292 and is representative of all different user cases (*i.e.* speech position, browsing position, etc.).

An analysis was done taking into account the above considerations with the following assumptions:

– For indoor AP antennas both consumer and enterprise omni-antenna patterns from the United Kingdom, Document 5A/246, were used. All ~~consumer~~ residential APs were assumed to be ~~desk~~ surface mounted.~~, 80% of enterprise devices were split between ceiling and surface mount and the other 20% were wall mount with a 50/50 split between ±90° rotation.~~

– For corporate and indoor public access locations indoor omni-antenna patterns from the United Kingdom, Document 5A/246, along with a few others were used. The antennas and orientations were selected to address each type of deployment, e.g. a high density deployment such as an arena or concert hall would utilize high performance ceiling antennas and wall antennas with a downward slope.

– For outdoor AP antennas, omni-directional patterns typical of those used by some U.S. cable operators were used along with the 6 and 12 dBi directional antennas, described in Document 5A/469 (Annex 29)~~, pointed in the horizontal direction~~. 70% of the~~The~~ outdoor APs are assumed to employ omni antennas~~devices were~~ all~~split 40% facing up, 40%~~ facing with main beam generally downward. ~~and 20%~~ 16% of outdoor APs employ a 6 dBi directional antenna~~facing horizontally~~ with 50 degrees of down tilt. 6% of outdoor APs employ a 12 dBi directional antenna with 30 degrees of down tilt.

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9 ITU-R R12-JTG 4567 348.

– 100% of the directional point-to-point antennas are assumed to be horizontally facing. For all point-to-point systems both azimuth and elevation discrimination need to be taken into consideration. The relationship may be described as presented in Recommendation ITU-R F.1336 equation 55 as:

$$G(\varphi,\theta) = G_0 + G_{hr}(\varphi) + R \cdot G_{vr}(\theta)$$

where:

$G_{hr}(\varphi)$ = the relative horizontal gain (discrimination) with an azimuthal offset angle ($\varphi$);

$G_{hr}(\theta)$ = the relative vertical gain (discrimination) with an elevation offset angle ($\theta$);

$R$ = horizontal gain compression ratio as the azimuth angle is shifted from 0° to $\varphi$, and scales the vertical relative gain

Average values for $R$ were developed for each 10 degree elevation angle increment from 0 to 90 degrees using average sidelobe factors from Table 4 of Recommendation ITU-R F.1336-4 and calculating $R$ for every 5 degree azimuthal increment from 0 to 355 degrees.

– Indoor and outdoor composite patterns were developed based on percentages of corporate, public access and residential user group device distributions and channel time allocations for client and AP. Note only the public access group contains any outdoor devices.

~~The result was a weighted average loss toward the satellite; *i.e.*, above 0 degree elevation, of 1.8 dB.~~A composite discrimination pattern for each indoor and outdoor environment was developed from typical antennas and placements as described above and are provided in Tables 4A and 4B.

TABLE 4A

**Indoor Composite Antenna Discrimination Pattern**

| Elev angle (deg) | Discrimination (dB) |
|---|---|
| 90 | 4.6 |
| 80 | 4.2 |
| 70 | 4.3 |
| 60 | 4.2 |
| 50 | 4.1 |
| 40 | 3.8 |
| 30 | 3.5 |
| 20 | 3.2 |
| 10 | 3.0 |
| 0 | 2.4 |

TABLE 4B

**Outdoor Composite Antenna Discrimination Pattern**

| Elev angle (deg) | Discrimination (dB) |
|---|---|
| 90 | 4.7 |
| 80 | 4.6 |
| 70 | 4.7 |
| 60 | 4.6 |
| 50 | 4.6 |
| 40 | 4.6 |
| 30 | 4.6 |
| 20 | 4.4 |
| 10 | 3.6 |
| 0 | 2.1 |

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#### 5.1.1.3.2.3 RLAN antenna heights

~~Table 3 provides a summary of the RLAN access point antenna heights. The~~The indoor corporate and public access antenna heights were ~~extracted from~~based on a building height distribution from a U.S. Energy Information Administration Survey10 ~~R15-WP5A-C-0114 Annex 24, an earlier version of M.[RLAN REQ-PAR].~~ Because the available data for buildings with 4 to 9 floors was aggregated together, this data was extrapolated using a best-fit curve to provide a separate probability for each floor. Within multi-story buildings, the distribution of RLANs is assumed to have an equal probability of occurring on any floor. Since there are more buildings with fewer floors, this results in a greater percentage of RLANs on lower floors and hence operating at lower heights. For example, the likelihood that an RLAN will be on the first floor may be calculated as: 1st Floor Probability = 1 Story Building Probability + 2 Story Building Probability/2 Floors … +10 Story Building (as well as buildings with 10 or more floors) Probability/10 Floors. A height of ten stories was selected as the maximum because the probability of RLANs on higher floors diminishes significantly even when taller buildings are considered. We can safely assume these numbers will apply to all corporate and indoor public access locations.

For all residential locations, the antenna heights were based on a U.S. Census Bureau Survey[11] applying the housing statistics in the same manner as building data above. A weighted average of the two sets of data, utilizing the distributions in Table 2 was calculated to give the indoor antenna height probability distribution by demographic.

While the general assumption that AP and client devices will be at the same height indoors, the same is not true outdoors. Practically speaking, the only outdoor devices are those in the Public

[10] United States Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey Data, Table B1.  Summary table: total and means of floorspace, number of workers, and hours of operation, 2012, revised: December 2016.

https://www.eia.gov/consumption/commercial/data/2012/#b1-b2.

11 United States Census Bureau, American Housing Survey (AHS), 2015 National - General Housing Data - All Occupied Units.

https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html#?s_areas=a00000&s_year=n2015&s_tableName=Table1&s_byGroup1=a1&s_byGroup2=a1&s_filterGroup1=t1&s_filterGroup2=g1&s_show=S.

Access space. For the outdoor Public Access APs, a significant portion, say 70% (e.g., most hotspots and municipal networks) will be strand or pole mounted at a height of approximately 7.5 meters, 5% rooftop mounted at 10.5 meters and 10% lower mounted on some wall at 4.5 meters. The remaining 15% located higher, e.g., outdoor stadiums, equally distributed between 13.5 and 28.5 meters. For client devices we can assume about 80% will be located on the ground at a height of 1.5 meters and 20% in a stadium at heights equally distributed between 4.5 and 22.5 meters. Outdoor Public Access users generally utilize the active RLAN channel to transmit from the AP 52% of the time and from the client 48% of the time, so AP and client locations are adjusted accordingly. Finally, an allowance of 0.785% is made for point-to-point systems which are equally distributed between 4.5 and 13.5 meters. The resulting probability distribution of indoor and outdoor RLAN antenna heights is provided in Table 5. Outdoor distribution is assumed to be the same for each demographic area.

The antenna heights are employed along with elevation angle to determine clutter loss to apply to the propagation path. In determining clutter loss ~~non-client~~ antenna heights are randomly selected, using the ~~a uniform~~ probability~~, in 3 meter steps distributed~~ distribution shown.~~ across the range shown~~. Either indoor or outdoor probabilities are employed depending on which interference source is being considered by the simulation. For practical reasons the height ~~randomly~~ selected is applied on a grid basis.

TABLE 5~~3~~

**Probability distribution of RLAN antenna heights**

| Height (m) | Indoor | | | Outdoor |
|---|---|---|---|---|
| | Urban | Suburban | Rural | |
| 1.5 | 62.17% | 61.64% | 60.61% | 38.1% |
| 4.5 | 26.39% | 26.73% | 27.40% | 6.7% |
| 7.5 | 8.60% | 8.75% | 9.05% | 37.7% |
| 10.5 | 1.50% | 1.52% | 1.56% | 4.1% |
| 13.5 | 0.59% | 0.60% | 0.61% | 2.8% |
| 16.5 | 0.33% | 0.34% | 0.34% | 2.7% |
| 19.5 | 0.20% | 0.20% | 0.21% | 2.7% |
| 22.5 | 0.13% | 0.13% | 0.13% | 2.7% |
| 25.5 | 0.06% | 0.06% | 0.06% | 1.3% |
| 28.5 | 0.02% | 0.02% | 0.02% | 1.3% |

| RLAN deployment | Antenna height (metres) |
|---|---|
| Urban | 1.5 to 28.5 |
| Suburban | 1.5, 4.5 |
| Rural | 1.5, 4.5 |

### 5.1.1.3.2.4 Path loss

Path loss is characteristic for each grid to satellite path defined by a number of contributing factors and accounted for in the following formula:

$$L_G = L_b + L_{CES} + L_{BEL} + L_X \tag{1}$$

where:

$L_b$: Transmission loss for slant distance computed;

$L_{CES}$: Earth to space clutter loss;

$L_{BEL}$: Building entrance loss only included when simulating indoor interference;

$L_x$: Cross-polarization discrimination.

Each of these factors is discussed below.

A liaison statement from ITU-R Working Parties (WPs) 3K and 3M to Document 5A/337 provides the following path loss advice for conducting agenda item 1.16 studies:

– With regard to the propagation model, Recommendation ITU-R P.619 should be used for earth-to-space paths.

– For building entrance loss Recommendation ITU R P.[BEL] (see Document 3/57(Rev.1)) should be used.

– For clutter Recommendation ITU R P.[CLUTTER] (see Document 3/51(Rev.1)) should be used. While the lower limit of the frequency does not include 5 GHz at this time, progress is being made to extend this. The current frequency range of applicability of section 3.3 of draft new Recommendation ITU-R P.[CLUTTER] is 10-100 GHz; however, if the deployment scenario is similar to that in section 3.3 of draft new Recommendation ITU R P.[CLUTTER] and in draft new Report ITU-R P.[CLUTTER_REP] (see Document 3/52), the model could reasonably be applied to frequencies as low as 5 GHz but limited to suburban and urban environments and antenna heights up to 6 meters. It is expected that extending draft new Recommendation ITU-R P.[CLUTTER] down to 5 GHz would provide more accurate results than Recommendation ITU-R P.452.

Provided with a note from Chairmen of Study Group 3 and Working Parties 3J, 3K and 3M to Chairman of Task Group 5/1 and various working parties (see Document 5A/357) is an embedded attachment containing an spreadsheet implementation of Recommendations ITU-R P.[Clutter] and ITU-R P.[BEL].

However with respect to the above the following editor's note was provided in Document 5A/469 (Annex 27), preliminary draft new Report ITU-R M.[RLAN REQ-PAR]:

*[**Editor's note:** Guidance was received from WPs 3K and 3M as shown below, WP 5A is seeking further clarification on applicability of clutter loss in 5 GHz range.]*

*Transmission Loss*

Transmission loss is computed for slant distance, and climate and other factors specific to each grid. Recommendation ITU-R P.619 provides the following propagation model for calculating transmission loss and can be expressed as:

$$L_b = 92.5 + 20 \log f + 20 \log d + A_g + A_D - G_S \quad \text{dB} \tag{2}$$

where:

$f$: frequency (5.2 GHz);

$d$: path length (km), slant distance from center of grid to satellite;

$A_g$: attenuation due to atmospheric gases (0.6 dB);

$A_D$: attenuation (dB) due to beam spreading (0 dB);

$G_S$: "gain" (dB) due to scintillation (0.65 dB).

Note that Recommendation ITU-R P.619 references a number of other recommendations that provide values for the last three variables:

$A_g$ may be approximated from Figure 6 and equation 28 of Recommendation ITU-R P.676-11, assuming a 45° elevation, as 0.6 dB.

The loss $A_D$ due to beam spreading may be calculated from equation 40 of Recommendation ITU-R P.618-12, with the following note: in regular refractive conditions, $A_D$ can be ignored at elevation angles above about 3° at latitudes less than 53°. Therefore it is assumed for the purpose of this study that $A_D$ is equals 0 dB.

Referring to Figure 12 and employing methods described in Recommendation ITU-R P.531-13, including its Figure 12, $P_{fluc}$ for 99% of the time was averaged over 6 years, adjusted for frequency and translated to gain/loss. The result is $G_S$ = 0.65 dB.

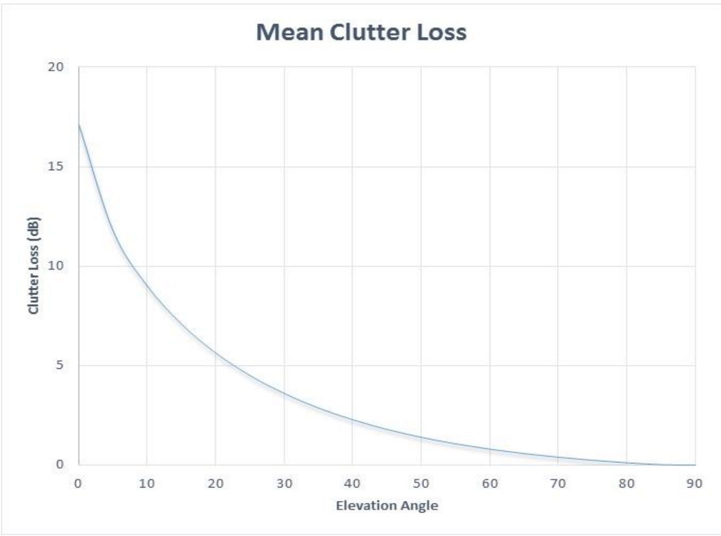
*Clutter Loss*

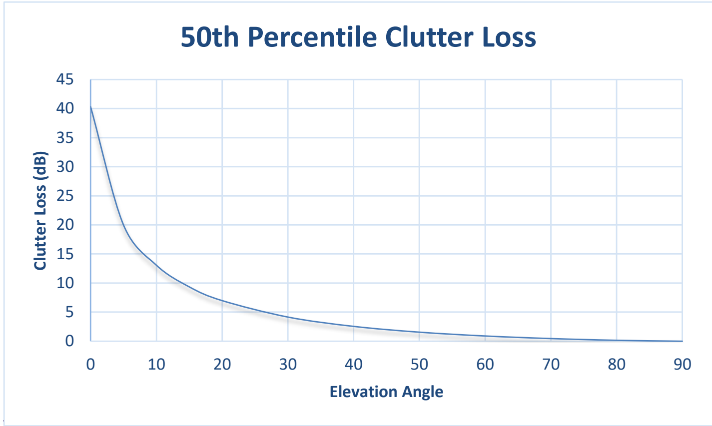
The scenario (Earth/ to space) under study is in accord with the deployment scenario defined in section 3.3 of Recommendation ITU-R P.[CLUTTER] (Recommendation ITU-R ITU-R P.2108）. Therefore, it is used for the calculation of clutter loss for ~~urban~~ grids where the randomly selected antenna heights are at or below 6 meters ~~and for all suburban grids since the maximum height defined in Table 3 is 4.5 meters~~.

For a study of this type where interference is aggregated from a large number of devices, a ~~50th percentile~~mean clutter loss curve was developed from the P.[Clutter] model. ~~In such a scenario the clutter loss will be greater than that shown for 50% of the grids and at or lower than that shown for 50% of the grids thus any differences are averaged out when aggregated.~~

FIGURE 1

**P.[Clutter] for suburban and urban grids with antenna heights ≤ 6 meters**





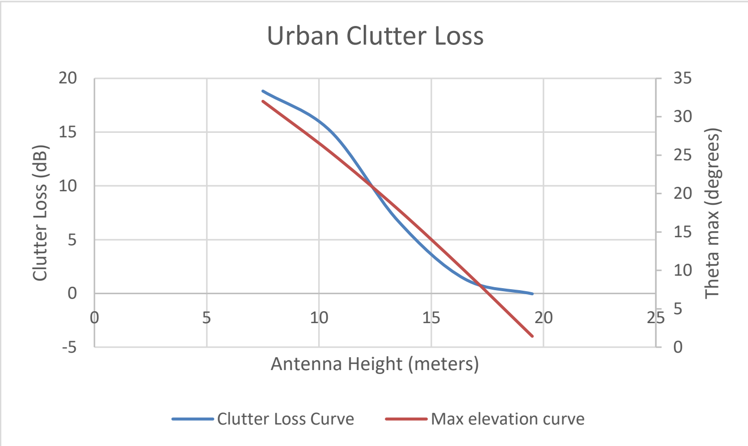

Embedded in Document 5A/114 (Annex 24)[12], is a spreadsheet implementation of Recommendation ITU-R P.452. Per the advice from WP 3M and 3K on restrictions for use of P.[Clutter], this study employs Recommendation ITU-R P.452 for all rural grids and for urban grids where the antenna height randomly selected is greater than 6 meters. The clutter loss values are calculated for the "sparse houses", and "urban" clutter (ground-cover) categories were applied to the rural and urban grids respectively. Theta max (θ°) provides the angle from the RLAN transmitter to the top of the clutter height. Therefore, if the spacecraft is at an elevation angle at or below theta max (θ°), clutter loss should be added. If the spacecraft is above theta max (θ°) of the respective clutter category, there is no clutter loss.

For rural grids only the lower 1.5 meter antenna height results in a possible clutter loss of 17.3 dB and only if the elevation angle is $\leq$ 1.4 deg. For urban grids Figure 4 provides clutter losses on the left vertical axis and maximum elevation angle theta max (θ°) on the right vertical axis versus the antenna heights displayed on the horizontal axis. When the randomly selected antenna height exceeds 6 meters for urban grids the clutter loss value corresponding to the antenna height is added to the path loss only if the elevation angle is equal to or less than theta max (θ°).

[12] This was an earlier version of preliminary draft new Report ITU-R M.[RLAN REQ-PAR].

FIGURE 2

**P.452 clutter loss for urban grids with antenna heights ≥ 6 meters**




*Building Loss*

The spreadsheet implementation of Recommendation ITU-R P.[Bel] (Recommendation ITU-R P.2109) ~~-~~provided by ITU-R Study Group 3 was used to generate a ~~50th percentile~~mean building entrance combined loss curve ~~for~~ representing 70% for traditional buildings~~;~~ and 30% for thermally-efficient buildings. ~~were not considered (see Figure 5). As previously noted in the clutter discussion above the actual loss will be greater than that shown for 50% of the grids and at or lower than that shown for 50% of the grids – thus any differences are averaged out when aggregated.~~

~~[Editor's Note: Other distributions of the building loss in Recommendation ITU-R P.2109 may be considered in the further study.]~~

Recommendation ITU-R P.2109 states: "The model makes the implicit assumption that terminals have an equal probability of location at any point within a building". However, it is not known whether the probability of building heights was taken into account in the development of the model. If not, based on the probability of distribution of indoor antenna heights previously discussed it is likely that attributing mean loss from Recommendation ITU-R P.2109 for the aggregate interference will lead to a significant understatement of actual loss and needs to be investigated.

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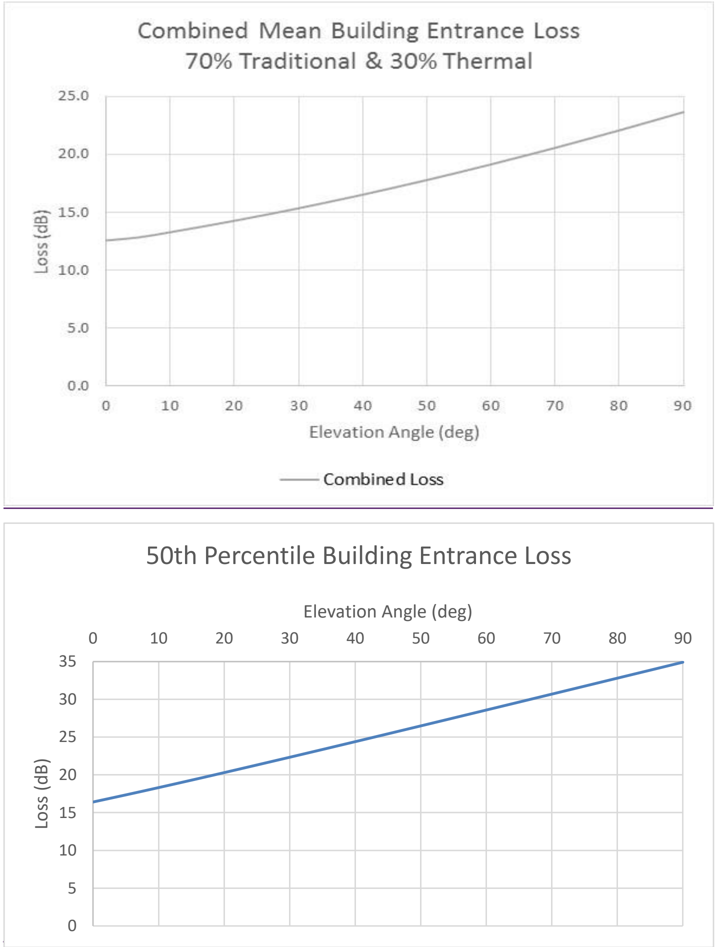
FIGURE 3

**P.[BEL] for indoor locations**




*Polarization Discrimination*

Polarization mismatch discrimination is the ratio at the receiving point between received power in the expected polarization and received power from a wave transmitted with a different polarization. Since RLAN devices are linearly polarized and the single system's satellite feeder links utilize circular polarization, some level of discrimination will exist. In the case of an interfering wave in linear polarization (the linear polarization vector can be derived from two circular polarization vectors, right- and left-hand rotation), the discrimination obtained at the victim receive antenna operating in circular polarization is provided in Recommendation ITU-R S.736-3 as:

$$L_x = -10 \log [1/2 (1 + 10^{-Dp(\varphi)/10}) \text{ dB}] \qquad (3)$$

where:

$Dp(\varphi)$: polarization decoupling of the receive antenna (dB).

This would result in 3 dB discrimination in the case of perfect decoupling. Since the operational environment will result in less than perfect decoupling, most studies will assume less than 3 dB. For this study we assumes 1.4 dB per ITU RR Appendix **8** (2.2.3).

#### 5.1.1.3.2.5 Number of RLAN devices simultaneously transmitting in the 5 150-5 250 MHz band

In order to calculate the contribution of RLANs in a grid to the aggregate interference into a 1.23 MHz CDMA carrier channel contained within the sole MSS system's FSS feeder link the density of RLAN transmissions in the 5 150-5 250 MHz band must first be determined. To calculate this number each grid is first categorized as belonging to one of three demographics, urban, suburban or rural. Then the demographic appropriate factors, shown in Table ~~4~~6, are applied to the grid population count. As a starting point the factors summarized in the tables in R12-JTG4567-C-0715-Annex 36 were reviewed and adjusted as discussed below. Three additional factors are also included: a time zone factor, a 5 GHz factor, and an overlap factor. In order to develop the factors on a demographic basis, the factors associated with each user group are weighted by the distributions provided in Table 2 and then aggregated across user ~~The~~groups. The~~se demographic~~ factors are defined as follows with additional discussion including user group details. ~~following as needed:~~

– Busy Hour factor is the percent of the population connected to an AP during the busy hour, but not necessarily transmitting or receiving;

– Time zone adjustment to account for satellite footprint covering multiple time zones. There are two different adjustments one for daytime and one for ~~nighttime~~evening;

– Market Factor is the percent of population with RLAN devices, *i.e.*, users; this has been updated to reflect latest information concerning Internet usage that might be expected from users within the FSS feeder antenna footprint;

– System Factor is the ratio of access points to users where an access point defines an RLAN cell. This has been adjusted to reflect inhabitants per household within the FSS feeder antenna footprint;

– Activity Factor is the percent of RLANs with transmissions;

– 5 GHz Factor is the ratio of RLANs that can operate in the 5 GHz range to the total number of RLANs including 2.4 GHz RLANs;

– Overlap Factor is the ratio of RLANs operating in the 5 150-5 250 MHz band to those operating across the 5 GHz range;

– Density refers to the density of RLAN transmissions in a channel in the 5 150-5 250 MHz band per inhabitant. It is simply the product of all other factors for each demographic. The daytime factors are used when the satellite being simulated passes over North America between the hours of ~~08~~02:00 and ~~20~~14:00. The ~~nighttime~~ evening factors are used when the satellite being simulated passes over the North America between the hours of ~~20~~14:00 and ~~08~~02:00 the remainder of the time.

TABLE 46

**Assumed demographic density factors**

| Daytime Factors | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Demographic** | **Busy hour** | **Time Zone Adjustment** | **Market** | **System** | **Activity** | **5 GHz** | **Overlap** | **Density** |
| Urban | 33.3% | 78.1% | 54.2% | 16.7% | 10.4% | 74.0% | 14.3% | 0.026% |
| Suburban | 32.3% | 78.1% | 53.8% | 19.8% | 10.1% | 74.0% | 14.3% | 0.029% |
| Rural | 30.2% | 78.1% | 53.0% | 31.4% | 9.5% | 74.0% | 14.3% | 0.040% |
| **Evening Factors** | | | | | | | | |
| **Demographic** | **Busy hour** | **Time Zone Adjustment** | **Market** | **System** | **Activity** | **5 GHz** | **Overlap** | **Density** |
| Urban | 71.5% | 90.4% | 54.2% | 16.7% | 10.4% | 74.0% | 14.3% | 0.064% |
| Suburban | 72.6% | 90.4% | 53.8% | 19.8% | 10.1% | 74.0% | 14.3% | 0.075% |
| Rural | 74.8% | 90.4% | 53.8% | 31.4% | 9.5% | 74.0% | 14.3% | 0.115% |

| Daytime Factors | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Demographic** | **Busy hour** | **Time Zone Adjustment** | **Market** | **System** | **Activity** | **5 GHz** | **Overlap** | **Density** |
| Urban | 71% | 91.8% | 79.0% | 20.2% | 25% | 74% | 14.3% | 0.275% |
| Suburban | 64% | 91.8% | 79.0% | 20.2% | 25% | 74% | 14.3% | 0.248% |
| Rural | 47% | 91.8% | 79.0% | 36.3% | 10% | 74% | 14.3% | 0.131% |
| **Nighttime Factors** | | | | | | | | |
| **Demographic** | **Busy hour** | **Time Zone Adjustment** | **Market** | **System** | **Activity** | **5 GHz** | **Overlap** | **Density** |
| Urban | 71% | 44.4% | 79.0% | 20.2% | 25% | 74% | 14.3% | 0.133% |
| Suburban | 64% | 44.4% | 79.0% | 20.2% | 25% | 74% | 14.3% | 0.120% |
| Rural | 47% | 44.4% | 79.0% | 36.3% | 10% | 74% | 14.3% | 0.063% |

*Busy Hour Factor*

In order to develop appropriate busy hour factors we first consider that user groups do not have the same busy hour. The corporate busy hour reasonably occurs during the work day, the public access sometime before or after work or during the lunch hour and the residential during the later evening hours. Since they all do not have the same busy hour then for any busy hour used it must be assumed the average number of users connected to an AP will be lower than the weighted average of all connected during their individual busy hour. It may be assumed that a significant percent of corporate and residential users are connected during their respective busy hours, (see the time zone discussion and Figures 7 and 8). Conversely, a lower percent of public access users connect during several busy periods throughout the day, e.g. a café, sports arena, and education facility each have different busy hours. Therefore, peak and secondary busy hours are considered. During the peak busy hour, which occurs at 21:00, 75% of residential users (1 in 4 household members not connected) are assumed to be connected while only 20% of corporate users are connected (1 in 5 workers still at the office or provide evening services, like restaurants or theater). During the secondary busy hour, which occurs at 10:00, 30% of residential users are assumed to be connected and 85% of corporate users are connected. For both hours 50% of public access users are assumed connected since it is unlikely either hour could be considered its busy hour and even if it was it is unlikely more than 50% of associated users would be connected.

*Time Zone Adjustment*

The footprint of the FSS feeder link satellite receive antenna covers a large geographic area spanning five time zones (See Figure 6). During the time the satellite passes over a location, say Lebanon, Kansas, the geographic midpoint of the United States, other RLANS will also be within the beam footprint but located in other time zones and thus will be operating outside their busy hour by as much as 3 hours. Because of this only a fraction of the area inside the footprint will ever be within its local busy hour at a given time. Therefore, peak traffic is determined by taking the highest average traffic across five consecutive time zones. Also, because time variant interference thresholds are defined in terms of outage per month, we need to consider traffic during the off peak hours. ~~defining peak traffic, that is, during the evening and early morning hours. The results of a study of traffic patterns for 50 countries[13] is used as the basis of developing time zone adjustment values.~~ A study[14] was conducted by Chitika Insights, an online ad company, to collect tens of millions of mobile- and desktop-based online ad impressions within the Chitika Ad Network to estimate time of day activity.

The results of the study are provided in Figures 7 and 8. In each graph "100%" refers to the hour at which traffic is at its peak. If a point is "70%", for instance, that means that the amount of traffic at that time is 70% of the traffic volume at the peak. The curves show the activity~~aggregate of~~ pattern ~~from the 50 countries, each normalized to their specific~~which has been converted from Coordinated Universal Time (UTC) to Central Standard Time (CST). ~~time zones.~~ Figure 7 provides traffic during~~as a percent of the busy hour during~~ the 02~~8~~:00 to ~~20~~14:00 (daytime) time period and figure 8 during the ~~20~~14:00 to ~~08~~02:00 (evening) time period. The two time periods were selected to capture the secondary and peak busy hours respectively. Of note is that the peak busy hour is in the evening at 20:00 driven by residential activity and the secondary busy hour is in the morning at 10:00 driven by corporate activity. Referring to the two charts and ~~T~~taking the highest average across five consecutive time zones ~~busiest~~ results in ~~91.8~~90.4% of the peak busy hour percent during the ~~daytime~~ evening hours and ~~44.4~~78.1% of the peak busy hour percent during the ~~evening/early~~ morning hours. These percentages represent the time zone adjustments and are accounted for in Table 6~~4~~.

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[13] ~~Comparison of User Traffic Characteristics on Mobile-Access versus Fixed-Access Networks, MIT, AKAMAI TECHNOLOGIES (July 2010) ("50 Country Study").~~

[14] https://chitika.com/browsing-activity-by-hour.

FIGURE 4

**Time zones within the FSS feeder link footprint**

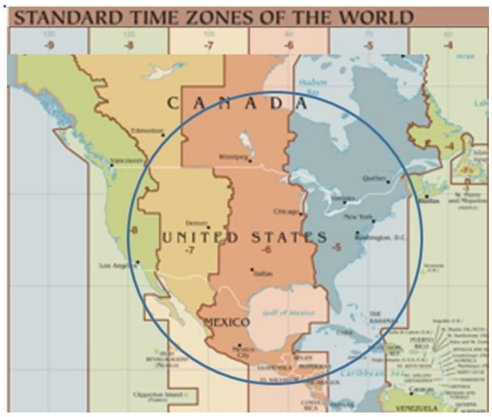
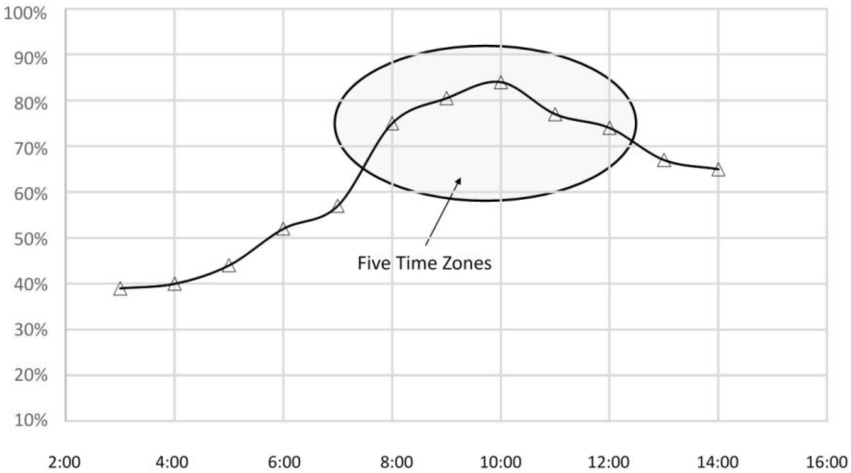



FIGURE 5

**RLAN aggregate traffic pattern ( daytime hours)~~Daytime RLAN aggregate traffic pattern for 50 countries~~**



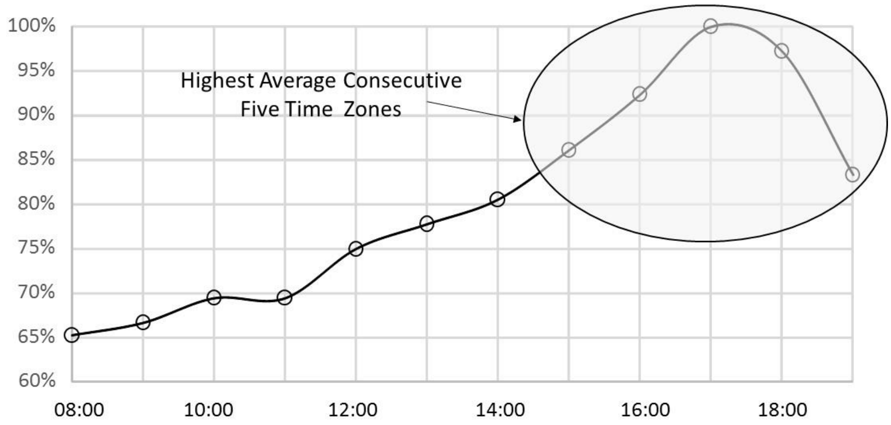
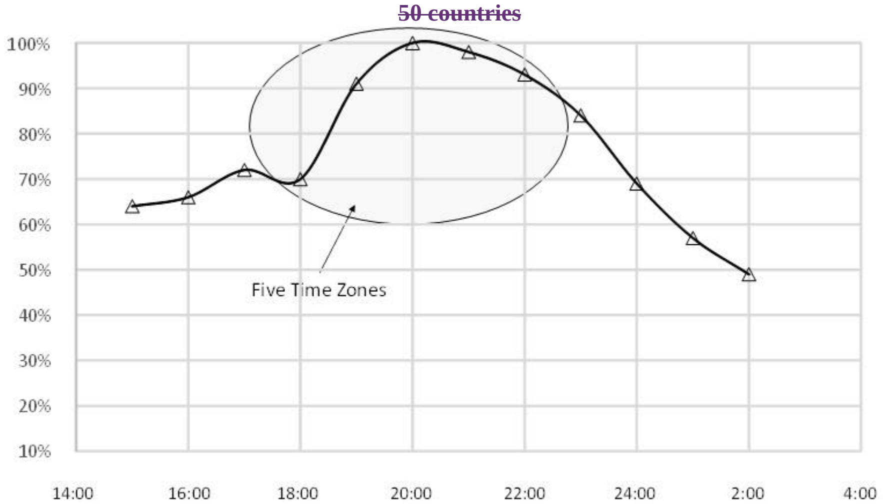
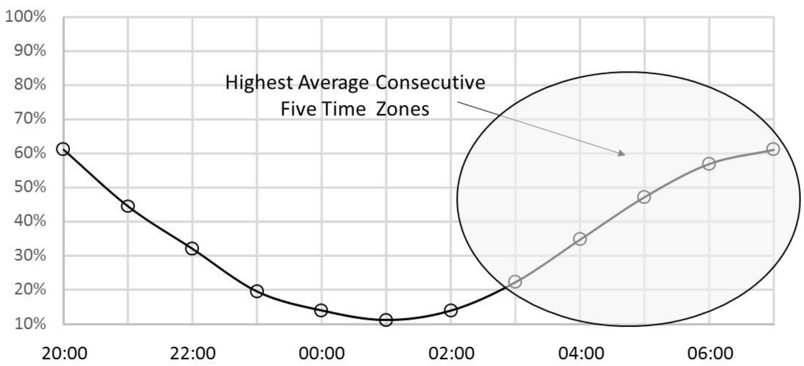



FIGURE 6

**RLAN aggregate traffic pattern (evening hours)~~Nighttime RLAN aggregate traffic pattern for 50 countries~~**






*Market Factors*

For the corporate market factor we note that from the U.S. Bureau of Labor Statistics[15] the highest percent of the population employed since 2008 has been approximately 63%. Assuming all of these have RLAN access, the corporate market factor is 63%. For the public access factor we can assume anyone that accesses the Internet is a potential RLAN user. Reviewing data[16]~~[17,18]~~ concerning the number of Internet users and populations of ~~Canada, the U.S.~~North America and ~~Mexico~~Latin America~~[19]~~, it may be shown that the percentage of the population accessing the Internet and hence conservatively RLANs, is 88.~~5~~1%, ~~88.4%~~ and ~~54.1~~62.4% respectively. We estimate that ~~the distribution of~~ population within the FSS feeder antenna footprint centered over the U.S. would include 100% of the U.S., a small percent of Canada, and 44% of Latin America. Resulting in an aggregate population distribution to be ~~4~~56% from North America~~Canada, 69% from the U.S~~ and ~~27~~44% from ~~Mexico~~Latin America. ~~From this~~For the Public Access user group we may assume 100% of the Internet access utilizes an RLAN, so from the above we compute the weighted average market factor to be ~~79~~83%%. For the residential user group, not all Internet access utilizes an RLAN[20], but 71% of U.S. broadband households are assumed to have some form of RLAN. While no similar information was found for Latin America we assume the RLAN adoption would be similar to Internet adoption on a relative basis to the North America, so a 50% RLAN adoption rate is assumed. Applying these additional factors we compute the weighted average residential market factor to be 52.8%.

*System Factors*

For the Corporate system factor, we consider that in an office environment an RLAN channel conservatively support 50 Mbps throughput and thus support 34 users at 1.5 Mbps adding 15% additional APs to cover common non-office space results in 29 users per AP or a system factor of

[15] https://data.bls.gov/timeseries/LNS12300000.

[16] https://www.internetworldstats.com/stats.htm.

~~[17] https://www.statista.com/topics/2237/internet-usage-in-the-united-states/.~~

~~[18] http://www.worldometers.info/world-population/population-by-country/.~~

~~[19] For this study Mexico is assumed to be a proxy for all of Latin America.~~

[20] http://www.parksassociates.com/blog/article/pr-01102017, Note the U.S. RLAN adoption rate is used as a proxy for North America.

3.45%. For the public access system factor it can be shown[21] that from a strictly capacity driven standpoint the number of users per AP could go as high as 200 to 300. It could also go as low as say 5 for a café setting. Considering from a cost-benefit perspective no more than 40% of the Public Access population is ever likely to be addressed, these numbers would increase further. Reviewing the breakdown of iPass distribution of public access venues, about 20% would be at the low end of number of users per AP, 20% at the high end and 60% at around 30 users per AP for a weighted average value of 70 for a system factor of 1.4%. For the Residential system factor, a review of publically available ~~Data~~data[~~22,~~ 23, 24] concerning inhabitants per household ~~show~~ provides numbers for ~~Canada,~~ U.S. and Mexico on the order of ~~2.4,~~ 2.5, and 3.8 respectively[25]. From this, for households with an operating RLAN we can ~~generally assume~~compute the residential system factor as[26] ~~that~~ the ratio of access points to users ~~for residences is the inverse or 0.417, 0.4, and 0.263~~. For North America, we assume 1.1 APs per house hold and for Latin America 1 AP. Applying the population distributions from above we may compute the weighted average ~~ratio~~ for residences to be 2.76 users per AP for a system factor 0.~~363~~36.2% or. ~~When originally determining system factors for Urban and Suburban areas it was assumed that 50% of the RLANs would be either be corporate or public access based, while the other 50% would be residential based. A review of best practices[27] concerning enterprise and public access design show the average number of clients supported by each AP will range from 24 to 100. As a worst case we assume 24 resulting in a ratio of access points to users for corporate and public access RLANs of 0.042. Applying 50% to 0.042 for corporate and public access RLANs and 50% to 0.363 for residential RLANs then summing the two we get a system factor of 20.2% for both Urban and Suburban demographics. For the rural demographic 100% of the RLANs can be assumed to be residential and hence the system factor is 36.3%.~~

*Activity Factor*

For the Corporate activity factor, we consider that in an office environment an RLAN channel will more heavily be used than anywhere else and a value of 25% which has been used previously is assumed. The assumed Public Access usage include all types of activity, both work and leisure related. The generally-accepted value of 10% is unduly low, so a value of 15% has been assumed. For the residential user group, 10% is considered most appropriate. However, we need to consider any additional APs that have been added to improve coverage which would in turn lower use on each node by dividing the load. As noted earlier, for North American residences it is assumed that one in ten households have an additional AP while for Latin America only one is assumed. Dividing 10% by 1.1 results in reducing the average activity in North American households to 9%. The

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[21] http://c541678.r78.cf2.rackcdn.com/appnotes/bpg-highdensity.pdf.

~~[22] http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/Page.cfm?Lang=E&Geo1=PR&Code1=35&Geo2=&Code2=&Data=Count&SearchText=Ontario&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=35.~~

[23] https://www.statista.com/statistics/183648/average-size-of-households-in-the-us/.

[24] https://www.efe.com/efe/english/life/mexican-households-have-an-average-of-3-8-members-843-in-monthly-income/50000263-2666718.

[25] Note U.S. and Mexican household sizes are used as a proxies for North America and Latin America.

~~[26] This assumes a single AP per household.~~

~~[27] www.ruckuswireless.com.~~

activity for the Latin American households remains at 10%. The weighted average is thus calculated as 9.5%.

*5 GHz Factor*

Since the RLAN density~~,~~ is based on other factors~~,~~ that include~~s~~ all RLANs, ~~that operate in both the~~regardless of band operating capability, e.g., 2.4 GHz~~ and 5 GHz bands~~, a median factor of 74% from Document 5A/420~~R15-WP5A-C-0420~~, table in section 7 is used to adjust the density to ~~just~~ include only those RLANs that have the capability to operate~~ing~~ in the 5 GHz band and possibly cause interference to the NGSO feeder uplink.

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**Overlap and Bandwidth factors**

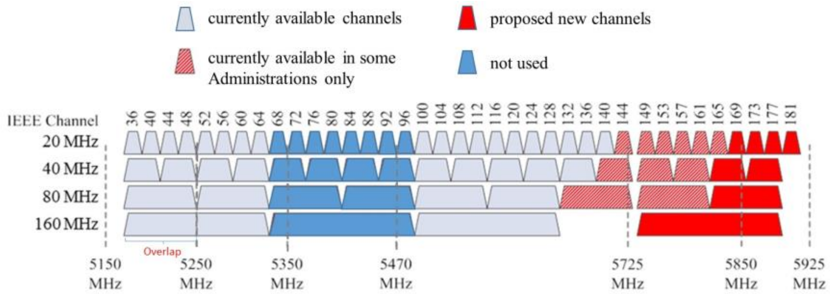
In order to determine the amount of RLAN interference that will be received by the CDMA carrier channel both overlap and various RLAN channel power spectral densities (PSDs) need to be accounted for. Detailed calculations to account for the overlap and PSDs are provided in the spreadsheet embedded as an attachment to Document 5A/469 (Annex 27), preliminary draft new Report ITU-R M.[RLAN REQ-PAR]. Results applicable to this study are provided utilizing this spreadsheet and are provided in Table ~~5~~10. It should be noted that for the spreadsheet the "Total number of RLANs in the 5 GHz range" is arbitrary and changing the number does not affect the results.

*Overlap Factor*

The 5 GHz factor reduces the total number of RLANs operating to just those operating in the 5 GHz band. This number needs to be further reduced to just those operating in the 5 150 to 5 250 MHz band that is shared with the FSS feeder links. Referring to Figure 9 (taken from Figure 1 of Document 5A/469 (Annex 27), preliminary draft new Report ITU-R M.[RLAN REQ-PAR] the 5 GHz channels over which the RLAN traffic load is spread are shown. It should be noted that it should exclude all channels in the 5 350 to 5 470 MHz range. Therefore, the spread sheet shown in Table ~~5~~ 9 has been adjusted to only include those channels available or potentially available for carrying RLAN traffic and results in an overlap factor of 14.3% which is included in Table ~~4~~ 9 to compute the RLAN transmission density numbers.

FIGURE 7

**RLAN channel overlap in the 5 150-5 250 band**




*Bandwidth or channelization factor ($\beta_f$)*

Because RLANs can operate with different bandwidths and all are larger than the CDMA carrier bandwidth of 1.23 MHz varying adjustments need to be made to account for differences in PSD presented to the victim CDMA carrier channel from RLANs transmitting with different bandwidths. The 16.5 MHz channel bandwidth originally used to calculate the ~~the~~ MSS bandwidth factor represents thirteen FDM 1.23 MHz CDMA carrier channels however the 1.23 MHz channel bandwidth is more appropriate for calculating any interference contribution to the FSS feeder link. Therefore, the spread sheet shown in Table ~~5~~ 9 has been changed from 16.5 MHz to 1.23 MHz and results in a bandwidth factor of 18.04 dB which is treated as a loss when calculating the interference contribution coming from a grid.

TABLE 9~~5~~

**Bandwidth factor calculation**

| | | | | | | |
|---|---|---|---|---|---|---|
| **MSS** | **1.23 MHz BW** | | | | | |
| | Average eirp | 19.0 | dBm | | | |
| | **TOTAL number of RLAN in the 5 GHz range** | | | **100** | | TOTAL |
| | Bandwidth in MHz | 160 | 80 | 40 | 20 | |
| | Distribution (JTG) | 15.0% | 50.0% | 25.0% | 10.0% | 100.0% |
| | Nb of RLAN for each bandwidth | 15 | 50 | 25 | 10 | 100 |
| | Nb of RLAN channels with bandwidth | 3 | 7 | 14 | 29 | |
| | Nb of RLAN per channel | 5.00 | 7.14 | 1.79 | 0.34 | |
| **TYPICAL CASE (see figure)** | | | | | | |
| | **Typical MSS overlap (Nb of channels)** | **1** | **1** | **1** | **1** | |
| | Nb of RLAN overlapping | 5.00 | 7.14 | 1.79 | 0.34 | **14.3** |
| | bandwidth factor | | **Ratio of overlapping RLAN** | | | **14.3%** |
| Channel Nb | Only 1 chan overlaps | -21.14 | -18.13 | -15.12 | -12.11 | |
| | Average | -21.14 | -18.13 | -15.12 | -12.11 | |
| | **Total eirp (dBm)** | 4.9 | 9.4 | 6.4 | 2.3 | **12.5** |
| | | **Average eirp per RLAN in 1.23 MHz** | | | | **0.98** |
| | | | | | **BW factor** | **18.04** |

### 5.1.1.4 Analysis

The analysis is based on a simulation. This simulation involves several large and dynamic data sets, as well as significant computation. Python was used to bring this data together in the simulation and produce results. The simulation tracks the path of ~~17 of the 34 active~~the satellites in the single MSS system's constellation as they orbit the Earth. Corresponding to a given satellite position, FSS feeder antenna pattern and population data enables us to calculate how each satellite "sees" the RLANs at any given point in time. With information concerning RLAN deployment and operating characteristics, along with population and demographic distributions, reasonably granular calculations may be made and results aggregated to give an accurate estimation of the interference present at the satellite at any given time.

Using the results of the simulation we calculate the peak and 2 minute average I/N ratios present at the satellite. Then we go on to consider the interference impact on the satellite system's deliverable channel and RF power capacity.

#### 5.1.1.4.1 Satellite Protection Definition

Recommendation ITU-R S.1432 Annex 1, Section 3, first paragraph states: "There are currently no Recommendations dealing with interference from co-primary allocated mobile systems into FSS systems." Nevertheless, WP 4A gave some guidance for FSS systems in their liaison statement, Document 5A/462, from which it appears the protection level of -12.2 dB I/N was extracted. However, it is unclear how this applies in the case of interference protection for a NGSO satellite that will experience time variant interference from an aggregation of RLANs when passing overhead. Never the less this study~~, will~~ assumes a protection benchmark of -12.2 dB as an initial point of comparison to ~~simulation~~ peak interference results then goes on to consider the time variant impact 2 minute averaged results have on the satellite system.

#### 5.1.1.4.2 Simulation Details

The single MSS satellite system using 5 150-5 250 MHz for feeder links consists of 34 active satellites in 1 414 km low earth orbits. Satellites complete an orbit approximately every 114 minutes. Therefore it takes approximately 15 minutes for a satellite footprint to pass over a point on the Earth. The simulation considered ~~17 of the 34~~multiple satellites. When any point of the U.S., Canada, or Latin America (as far south as Northern part of Brazil) was within line of sight of a satellite under study the aggregate interference was calculated every 30 seconds, with each calculation constituting a sample. ~~The~~ Each satellite simulation was run for a ~~two~~ six day period approximately ~~25~~ 76 satellite orbits to ensure reasonable day and evening busy hour representation.

This study assumes that since calculations are made every 30 seconds, the value of interference calculated exists for the entire 30 second period. To calculate the 2 minute averaged interference exceeding -12.2 dB I/N every four samples are averaged then a count is made of the times the two minute averaged values exceed -12.2 dB and the satellite with the greatest count is used. This count is multiplied by 2 minutes and then divided by the total service minutes the satellite provides during the simulation to get the percent of time -12.2 dB is exceeded. This method is repeated for other values of I/N.

#### 5.1.1.4.3 Calculations

The steps below describe the calculations performed to determine interference levels received, interference protection compliance, and related performance degradation experienced by the satellite MSS system.

**Step 1:**

At any instant in time the FSS receive antenna geographical footprint defines a number of grids containing some number of RLANs transmitting energy in the direction of the MSS satellite. The positions of the satellite and each grid center are used to determine the slant distance (d) and elevation angle (θ) to be associated with each grid. Using the population count and demographic type, obtained from the LandScan™ database, the number of RLANs simultaneously transmitting in the 5 150-5 250 MHz band is computed as shown in equation 4.

$$R_G = S_p \times C_D \tag{4}$$

where:

$R_G$: Number of RLANs transmitting in the (5 150-5 250 MHz band within a given grid;

$S_p$: Population within a grid;

$C_D$: Density corresponding to grid demographic from Table 8~~4~~.

**Step 2:**

This step calculates the aggregate power (dBm) from each grid presented to the satellite transponder based on average RLAN e.i.r.p. and all losses characteristic to the link defined by the grid's slant distance (d) and elevation angle (θ).

$$P_G = E_r - D_R + 10\log(R_G) - L_G + G_f - \beta_f \quad (5)$$

where:

$P_G$: Aggregate power at the input of the FSS feeder transponder from a given grid;

$E_r$: Average e.i.r.p of RLANs;

$D_R$: Average antenna discrimination of RLANs in a grid in the direction of the MSS satellite;

$L_G$: Total path loss including transmission loss and other propagation losses for grid to satellite slant distance;

$G_f$: Receive gain of the satellite feeder antenna in the direction of the grid center point (includes feeder loss);

$\beta_f$: Bandwidth factor, average ratio of (e.i.r.p. at the receiver (assuming no losses) to the power that would be present in the CDMA carrier receive channel) in dB.

**Step 3:**

Every 30 seconds this step aggregates the power from each grid located within the FSS feeder link antenna line of sight and converts the result to dBW:

$$\mathrm{I}_{in} = 10\ x\ log\left(\sum_{k=1}^{N_G} 10^{(P_G/10)}\right) - 30 \quad (6)$$

where:

$I_{in}$: Simulated external interference power into CDMA carrier feeder channel at satellite transponder where the calculation of $P_G$ ~~including~~ includes building loss, and employs indoor antenna discrimination and indoor antenna height probabilities for all grid calculations;

$I_{out}$: Simulated external interference power into CDMA carrier feeder channel at satellite transponder computed in the same manner as $I_{in}$ but in which the calculation of $P_G$ excludes building loss, and employs outdoor antenna discrimination and outdoor antenna height probabilities for all grid calculations;

$N_G$: Number of grids within FSS feeder antenna footprint.

**Step 4:**

The simulation calculates both ~~value~~ $I_{in}$ and $I_{out}$ as described. ~~above includes the building loss for all grids.~~ Then calculates $I_{agg}$ ~~is step~~ takinges into account that ~~94.7~~98% of RLANs are indoor and ~~5.3~~2% are outdoor. ~~For the satellite with the highest interference sample $I_{in}$, calculated in step 3, a simulation without BEL is performed to find the interference from outdoor RLANs ($I_{out}$). Then the worst case combination of $I_{in}$ and $I_{out}$ is used to determine the effective aggregate interference into the FSS feeder link from both indoor and outdoor RLANs.~~ This may calculated as:

$$I_{agg} = 10\ x\ \log\left[0.98\cancel{47}\ x\ 10^{\left(\frac{I_{in}}{10}\right)} + 0.02\cancel{53}\ x\ 10^{\left(\frac{(I_{out}}{10}\right)}\right] \quad (7)$$

where:

~~$I_{out}$: Simulated external interference power into CDMA carrier feeder channel at satellite transponder excluding building loss for all grid calculations~~

$I_{agg}$: Effective aggregate RLAN interference power into a CDMA carrier channel of the FSS FDM feeder channel at satellite, includes impact of both indoor and outdoor RLANs

**Step 5:**

This step calculates aggregate RLAN interference relative to noise levels at the satellite

$$I/N = I_{agg} - N_{up} \tag{8}$$

where:

$N_{up}$: Satellite kTB.

**Step 6:**

This step calculates the percent non-compliance with a given I/N protection threshold, i.e. the percent of the service time the 2 minute averaged interference exceeds a given threshold. Percent non-compliance is calculated for -12.2 , -11, -10, -8, and -6, dB I/N thresholds. Assuming an orbit time of 114 minutes and a service time over the study area of 15 minutes we can determine the total service time provided during the simulation as:

$$T_{scv} = T_{sim} \text{ x } 15/114 \tag{9a}$$

where:

$T_{scv}$: Service time

$T_{sim}$: Simulation time

For each I/N the 2 minute averaged results are compared to determine a count of number of times the I/N value is exceeded (i.e. non-compliance). The percent non-compliance is then calculated as:

$$N_c = C_{nc} \text{ x } 2/T_{scv} \tag{9b}$$

where:

$N_C$: Percent non-compliance

$C_{nc}$: Count of non-compliance, i.e. number time I/N exceeded

**Step 7:**

In this step we consider what would constitute an appropriate time variant I/N threshold by consideration of the impact of RLAN transmissions on the channel capacity of the MSS satellite system.

Table 10 provides an adjusted capacity impact analysis of that presented by a Sector member in Document 5A/550 (pages 30-32). The adjustments are made to account for: (1) the fact that RLAN channels only overlap 53 out of the satellite's 104 available CDMA channels and, (2)the fact that degradation takes place only when non-compliance occurs, i.e., $N_c$ percent of the time.

First the capacity reduction is calculated using the techniques described in Document 5A/550. Next the reduction is adjusted by 53/104 for channel overlap. Finally, it is adjusted for the non-compliance times calculated in step 6. The far right column of Table 10 is provided as a check against the calculation results shown in Figure 16 of Document 5A/550. Row V of Table 10 below provides the relative capacity and is basically the same as Document 5A/550 for a degradation of 1.8 dB that is 0.

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TABLE 10

**Impact of RLAN Interference on Satellite Channel Capacity**

| Ref. | Parameter | Dimensions | Values | | | | | |
|---|---|---|---|---|---|---|---|---|
| A | Reference Protection Threshold (I/N) | dB | -12.2 | -11.0 | -10.0 | -9.4 | -6.0 | -2.9 |
| B | Uplink Noise Power Spectral Density No | dBW/Hz | -201.3 | -201.3 | -201.3 | -201.3 | -201.3 | -201.3 |
| C | Average Received Interference Power Spectral Density from simulation (exceeding the protection level above) Ia | dBW/Hz | -212.2 | -211.5 | -210.9 | -300.0 | -300.0 | -204.2 |
| D | Noise Rise on Uplink (degradation) | dB | 0.34 | 0.39 | 0.45 | 0.00 | 0.00 | 1.80 |
| E | Uplink Eb/(Io+No), design objective | dB | 19.9 | 19.9 | 19.9 | 19.9 | 19.9 | 19.9 |
| F | Rx signal/user/satellite | dBW/1.23 MHz | -168 | -168 | -168 | -168 | -168 | -168 |
| G | Log Bandwidth | dB | 60.90 | 60.90 | 60.90 | 60.90 | 60.90 | 60.90 |
| H | Rx signal density | dBW/Hz | -228.9 | -228.9 | -228.9 | -228.9 | -228.9 | -228.9 |
| I | Downlink No | dBW/Hz | -203.9 | -203.9 | -203.9 | -203.9 | -203.9 | -203.9 |
| J | Avg data rate (2400 bps) | dB bit/sec | 33.8 | 33.8 | 33.8 | 33.8 | 33.8 | 33.8 |
| K | CDMA Downlink Intra-system Interference Io per channel | dBW | -148.7 | -148.7 | -148.7 | -148.7 | -148.7 | -148.7 |
| L | Downlink Io density | dBW/Hz | -209.60 | -209.60 | -209.60 | -209.60 | -209.60 | -209.60 |
| M | Downlink (No + Io) | dBW/Hz | -202.9 | -202.9 | -202.9 | -202.9 | -202.9 | -202.9 |
| N | Down link Eb/(No+Io) | dB | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |
| O | Required Eb/(No+Io+Ia) [= Overall Eb/(No+Io+Ia)MIN] | dB | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| P | Coherent combining gain | dB | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Q | Simulated Uplink Eb/(No+Io+Ia) (E - D) | dB | 19.56 | 19.51 | 19.45 | 19.9 | 19.9 | 18.1 |
| R | Required Downlink Eb/(No+Io, red) to maintain 1.01 overall, since uplink is degraded. (O- Q linear) | dB | 1.0711 | 1.0718 | 1.0726 | 1.0664 | 1.0664 | 1.0957 |
| T | Increase (Incr ) in Downlink Eb/(No+Io) (R - N) | dB | 0.0046 | 0.0054 | 0.0062 | 0.0000 | 0.0000 | 0.0292 |
| U | Increase (Incr ) in Downlink Eb/(No+Io) | linear | 1.0011 | 1.0012 | 1.0014 | 1.0000 | 1.0000 | 1.0068 |
| V | New reduced downlink Io required = Io, red, to maintain 1.01 (O) overall (see equation for Io, red) | dBW/Hz | -209.621 | -209.624 | -209.628 | -209.599 | -209.599 | -209.738 |
| W | Reduction in downlink Io required to maintain Eb/(Io+No)MIN (L - V) | dB | 0.022 | 0.025 | 0.029 | 0.000 | 0.000 | 0.139 |
| X | Relative Capacity | linear | 0.9950 | 0.9942 | 0.9933 | 1.000 | 1.000 | 0.968 |
| Y | Percent capacity reduction in a single CDMA Channel | | 0.502% | 0.582% | 0.666% | 0.000% | 0.000% | 3.15% |
| Z | Percent satelite channel capacity reduction accounting for 53/104 available channels per polarity | | 0.256% | 0.296% | 0.340% | 0.000% | 0.000% | 1.61% |
| AA | Nc, percent of service time I/N threshold in (A) exceeded | | 9.678% | 4.751% | 1.056% | 0.000% | 0.000% | 0.000% |
| AB | Long term impact (capacity reduction) assuming degradation takes place only $N_c$ percent of the service time | | 0.025% | 0.014% | 0.004% | 0.000% | 0.000% | 0.000% |

**Step 8:**

In this step we consider what would constitute an appropriate time variant I/N threshold by consideration of the impact of RLAN transmissions on the RF power amplifier capacity of the MSS satellite system.

Table 11 provides an adjusted RF power impact analysis of that presented by a Sector member in Document 5A/550 (pages 33-38). The adjustment is made to account for: the fact that degradation takes place only when non-compliance occurs, i.e., $N_c$ percent of the time.

First the net loss in power available for RF user transmissions is calculated using the techniques described in Document 5A/550. Next the net loss is adjusted for the non-compliance times calculated in step 6. In the far right column of Table 11 is provided as a check against the calculation made in Table 4 of Document 5A/550. Other than some rounding errors in document 550 the results are shown to be the same.

TABLE 11

**Impact of RLAN Interference on Satellite RF Power**

| Ref | Parameter | Dimension | Value | | | | | |
|---|---|---|---|---|---|---|---|---|
| A | Reference Protection Threshold (I/N) | dB | -12.2 | -11.0 | -10.0 | -9.4 | -6.0 | 10.0 |
| B | Uplink Noise Power Spectral Density | dBW/MHz | -141.5 | -141.5 | -141.5 | -141.5 | -141.5 | -141.5 |
| C | Average Received Interference Power Spectral Density from simulation (exceeding the protection level above) | dBW/MHz | -152.2 | -151.5 | -150.9 | -300 | -300 | -132.0 |
| D | Noise Rise on Uplink (degradation) | dB | 0.36 | 0.41 | 0.47 | 0.00 | 0.00 | 10.00 |
| E | Satellite Uplink Receive Antenna Gain | dBi | 6.37 | 6.37 | 6.37 | 6.37 | 6.37 | 6.37 |
| F | Satellite Rx Line Loss | dB | -2.6 | -2.6 | -2.6 | -2.6 | -2.6 | -2.6 |
| G | Received RLAN Interference power @LNA = (C + E + F) note, study simulation results in (C) already included antenna gain and line loss | dBW/MHz | -152.2 | -151.5 | -150.9 | -300.0 | -300.0 | -128.2 |
| H | Nominal Transponder Gain (Includes RX and TX Line Losses) | dB | 122.7 | 122.7 | 122.7 | 122.7 | 122.7 | 122.7 |
| I | TX Line Loss | dB | -2.1 | -2.1 | -2.1 | -2.1 | -2.1 | -2.1 |
| J | RLAN Interference power generated by satellite PA = (G + H -F - I) | dBW/MHz | -24.78 | -24.14 | -23.55 | -172.60 | -172.60 | -0.83 |
| K | RLAN Interference power per MHz generated by satellite | Watts/MHz | 0.0033 | 0.0039 | 0.0044 | 0.0000 | 0.0000 | 0.83 |
| L | Nominal RF Power available (including eclipse) | Watts | 268 | 268 | 268 | 268 | 268 | 268 |
| M | Total RLAN Interference power generated by satellite (53 channels) | Watts | 0.08% | 0.09% | 0.11% | 0.00% | 0.00% | 20.09% |
| N | CDMA Downlink Overhead as % of Sat Peak Power | | 15% | 15% | 15% | 15% | 15% | 15% |
| O | Satellite power overheads (CDMA) without Interference | | 20.20% | 20.20% | 20.20% | 20.20% | 20.20% | 20.20% |
| P | Downlink Degradation (see figure 15 document 550) | dB | 0.055 | 0.06 | 0.065 | 0.05 | 0.05 | 0.55 |
| Q | New power overhead w/interference (O + P) | | 20.46% | 20.48% | 20.50% | 20.43% | 20.43% | 22.93% |
| R | Total Nominal Satellite power (including eclipse) | | 100% | 100% | 100% | 100% | 100% | 100% |
| S | Available Satellite Power for RF transmission with interference = (R - Q) | | 79.5% | 79.5% | 79.5% | 79.6% | 79.6% | 77.1% |
| T | Wasted Available power due to Interference = (M + Q - O) | | 0.34% | 0.37% | 0.41% | 0.23% | 0.23% | 22.82% |
| U | Wasted Available power due to Interference = T/(R - O) | | 0.42% | 0.47% | 0.52% | 0.29% | 0.29% | 28.60% |
| V | Delta T/ T corresponding to downlink degradation P (see figure 15 document 550) | | 1.35% | 1.50% | 1.60% | 1.65% | 1.90% | 12.0% |
| W | Additional % power to overcome delta T/T = V * (R-O) | | 1.08% | 1.20% | 1.28% | 1.32% | 1.52% | 9.58% |
| X | Total lost power available for RF (user transmissions) = (T + W) | | 1.416% | 1.572% | 1.689% | 1.551% | 1.750% | 32.396% |
| Y | Total net lost power available for RF (user transmissions) = X/(R - O) | | 1.774% | 1.970% | 2.116% | 1.943% | 2.193% | 40.597% |
| Z | Nc, percent of service time I/N threshold in (A) exceeded | | 9.678% | 4.751% | 1.056% | 0.000% | 0.000% | 0.000% |
| AA | Long term impact (net power lost) assuming degradation takes place only $N_c$ percent of the service time | | 0.172% | 0.094% | 0.022% | 0.000% | 0.000% | 0.000% |

### 5.1.1.5 Results/Conclusions

Appendix 1 provides further descriptive information concerning the simulation.

Table ~~6~~ 12 provides the calculation of ~~worst case~~the peak aggregate interference $I_{agg}$ simulated assuming 2~~5.3~~% are operating outdoors and 98~~4.7~~% are operating indoors.

TABLE ~~6~~12

**Calculation of total aggregate interference $I_{agg}$**

| Environment | Aggregate interference by environment (dBW) | Aggregate interference by environment (Watts) | % of RLANs by environment | Apportioned interference (Watts) | Total aggregate Interference (dBW) |
|---|---|---|---|---|---|
| Outdoor | -137.2 | 1.91E-14 | 2.0% | 3.81E-16 | |
| Indoor | -151.5 | 7.14E-16 | 98.0% | 7.00E-16 | |
| Indoor + Outdoor | | | | 1.08E-15 | -149.7 |

| Environment | Aggregate interference by environment (dBW) | Aggregate interference by environment (Watts) | % of RLANs by environment | Apportioned interference (Watts) | Total aggregate Interference (dBW) |
|---|---|---|---|---|---|
| Outdoor | -141.5 | 7.14E-15 | 5.3% | 3.78E-16 | |
| Indoor | -169.3 | 1.17E-17 | 94.7% | 1.10E-17 | |
| Indoor + Outdoor | | | | 3.89E-16 | -154.10 |

The maximum peak value of the aggregate RLAN interference calculated, based on samples collected from both indoor and outdoor RLAN interference simulations was -149.7~~54.1~~ dBW and therefore an I/N value of -~~13.8~~9.4 dB was never exceeded, ~~safely below~~2.8 dB above the comparison benchmark of -12.2 dB. However, referring to Table 10 we note that the maximum time variant CDMA satellite channel capacity lost is 0.025%, which is a loss of 0.256% over 9.68% of the service interval. Likewise, referring to Table 11 we note that the maximum time variant RF power loss is 0.172%, which is a loss of 1.774% for 9.68% of the service interval. In each case, table 10 and 11 show that higher losses can be experienced but for shorter intervals, resulting in less long-term impact.

It is important that realistic conclusions from this study follow. In this respect, Recommendation ITU-R S.1427 provides the following:

*NOTE 1 – The impact of the aggregate long-term interference due to WAS/RLANs into non-GSO MSS feeder links, in terms of the reduction in non-GSO MSS satellite capacity, should also be considered in conjunction with the methodology proposed in the above recommends. This is to ensure that the interference power captured by the non-GSO MSS satellites should account for a reduction in available satellite capacity less than or equal to 1%. This value may require further study.*

In neither time variant case provided above does the long term impact approach 1%.

Although for a one-on-one interference study it might be appropriate to simply consider the maximum power allowed as contributing to the interference, for a study involving aggregate interference from a large number of transmitters, the variation in operational characteristics should be considered. This study did this by using conservative operational e.i.r.p. values. These values were based on the maximum average[28] conducted power and antenna combination tested across all Modulation Coding Scheme (MCS), channel bandwidths, and antenna combinations during their certification process. However, these values would be much lower if averaged across all combinations that would likely be employed during normal operation. The resulting e.i.r.p. distribution table would therefore have much lower numbers across all distributions than that used in this study.

It was noted in the building loss discussion that there is the possibility that if ITU-R P.2109 did not account for building height probabilities, if not the P.2109 significantly understates the building loss and needs to be investigated.

Considering these additional factors, it is highly probable the peak protection benchmark of -12.2 dB I/N would be achieved and regardless 1% long-term impact is not exceeded.

~~Considering this outcome~~Therefore, it is evident that allowing RLANs to operate both indoors and outdoors ~~and at~~ with higher powers in the 5 150-5 250 MHz poses no harmful interference to the single operational MSS system, when sharing the band with the system's FSS feeder uplink.

[28] Maximum average here refers to the combination with the maximum e.i.r.p. when the conducted power for that combination was averaged over the test time.

# APPENDIX 1 OF THE STUDY IN SECTION 5.1.1

## Simulation Details

The simulation tracked ~~17 of the 34~~a number of active MSS satellites over ~~two~~ six days. Figure 10 shows the typical path of a satellite with a 52 degree inclination over one 24 hour period.

FIGURE 10

**24 hour path of satellite (52º inclination)**

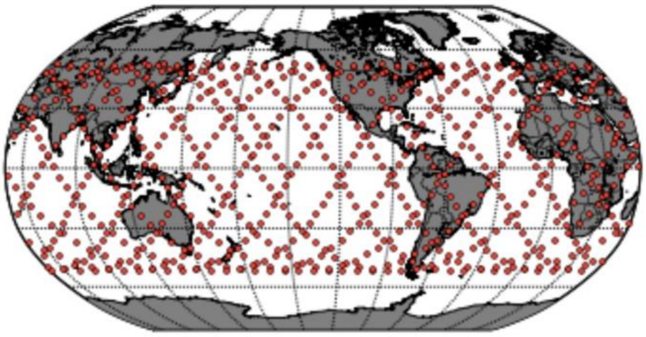

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Figure 11 shows the where the geo-population data was compiled from the Oak Ridge National Laboratory's (ORNL) LandScan™ database for the study area of interest. ~~Areas in black indicate the presence of population.~~ Whenever the satellite's feeder receive antenna has line of site to these areas the aggregate power from the corresponding in band RLAN transmissions is calculated. Otherwise a value of -300 dBW is assigned to a sample.

FIGURE 11

**Latitude, longitude considered in the simulation**

Table <u>13</u>~~7~~ provides statistics for the simulation study area. Of particular interest is that while rural locations comprise 98% of the area they only account for 40% of the population. It also may be observed that suburban areas will constitute the greatest interference contribution.

TABLE ~~7~~<u>13</u>

**Geo-population statistics of the study area**

| Demographic | # of Grids | Percent of total area | Population | Population % |
|---|---|---|---|---|
| Urban | 272 | 0.10% | 107770056 | 16.63% |
| Suburban | 5275 | 1.90% | 280954100 | 43.34% |
| Rural | 272701 | 98.01% | 259481645 | 40.03% |
| Total | 278248 | | 648205801 | |

Figure 12 shows the total aggregate interference power calculated for each pass of satellite M094 over the study area approximately once every 114 minutes. Note time is Greenwich Mean Time (GMT) and 00:00 GMT is 18:00 U.S. mountain time so we see the variation between day and night.

FIGURE 12

**M094 satellite simulated aggregate interference**

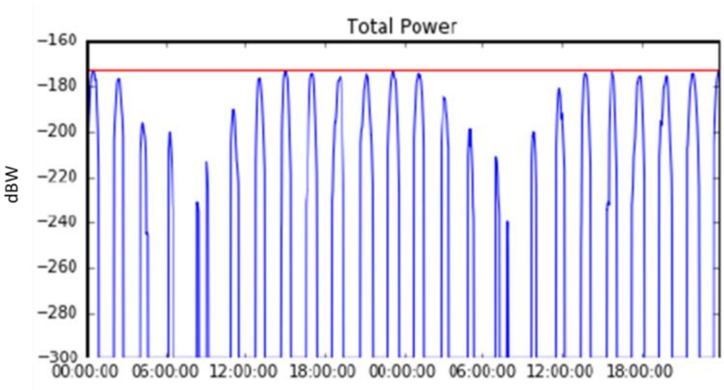
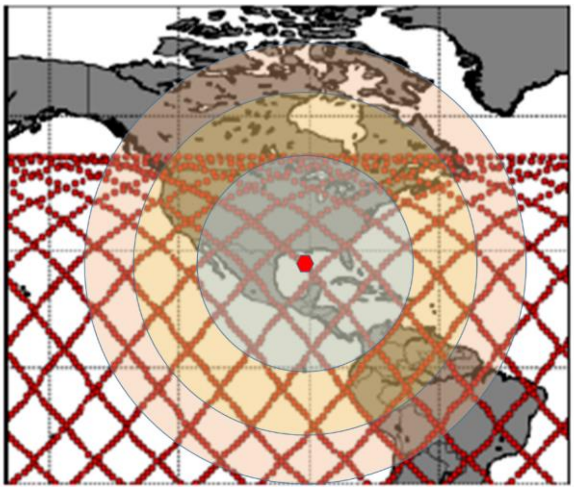



Figure 13 shows the 0, -3 and -5 dBi feeder receive antenna footprint coverage at one of the sample points in the daytime path of satellite M094. This is the point at which the maximum sample value of aggregate interference was calculated.

FIGURE 13

**M094 satellite at maximum simulated aggregate interference**



~~APPENDIX 2~~

## ~~**Nomenclature**~~

~~$\alpha$: Expected value of channel activity~~

~~$B$: Channel bandwidth~~

~~$B_{adj}$: Band adjustment to from 5 GHz band to FSS feeder link band~~

~~$B_c$: CDMA carrier channel bandwidth~~

~~$\beta_f$: Bandwidth factor (average ratio of e.i.r.p. at the receiver (assuming no losses) to the power that would be present in the CDMA carrier receive channel) in dB~~

~~$C_D$: Density corresponding to grid demographic from table 4~~

~~$D_R$: Average antenna discrimination of RLANs in a grid in the direction of the MSS satellite~~

~~$E_d$: Peak e.i.r.p per user from satellite~~

~~$E_r$: Average e.i.r.p. of RLANs~~

~~$E_u$: Nominal e.i.r.p. of gateway earth station~~

~~$f$: Neighboring cell interference factor~~

~~$G_f$: Antenna gain of the satellite feeder antenna in the direction of the grid center point~~

~~$G_r$: Receive antenna gain user terminal (service link)~~

~~$G_t$: Satellite transmit antenna gain (service link)~~

~~$I_{agg}$: Effective aggregate RLAN interference power into a CDMA carrier channel of the FSS FDM feeder channel at satellite includes impact of both indoor and outdoor RLANs~~

~~$I_{in}$: Simulated external interference power into CDMA carrier feeder channel at satellite transponder including building loss for all grid calculations~~

~~$I_{out}$: Simulated external interference power into CDMA carrier feeder channel at satellite transponder excluding building loss for all grid calculations~~

~~$I_e$: Intra-system interference spectral density in service downlink at user terminal~~

~~$I_o$: Intra-system interference spectral density~~

~~$I_s$: Intra-system interference spectral density in feeder up link at satellite~~

~~$I_{up}$: Intra-system interference feeder uplink~~

~~$k$: Boltzmann's constant 1.38 x $10^{-23}$W/s/K~~

~~$L_b$: Transmission loss for slant distance computed~~

~~$L_{BEL}$: Building entrance loss~~

~~$L_{CES}$: Earth to space clutter loss~~

~~$L_G$: Total grid path loss including transmission loss and other propagation losses~~

~~$L_f$: Antenna feed loss~~

~~$L_{fdr}$: Path loss computed for feeder uplink~~

~~$L_{sev}$: Path loss computed for service downlink~~

~~$L_x$: Cross-polarization discrimination~~

~~$m$: Number of times in which the averaged aggregate interference level calculated exceeds the threshold interference level~~

~~$M_S$: System margin~~

~~$N_b$: Number of simultaneous CDMA user channels a satellite supports in a beam (cell)~~

~~$N_c$: Number of simultaneous user channels supported in each CDMA carrier channel~~

~~$N_{dn}$: KTB noise user terminal~~

~~$N_e$: User terminal noise spectral density~~

~~$N_G$: Number of grids within FSS feeder antenna footprint~~

~~$N_o$: kT noise spectral density~~

~~$N_s$: Satellite noise spectral density~~

~~$N_{sat}$: Number of simultaneous CDMA user channels a satellite supports~~

~~$N_{up}$: Satellite kTB~~

~~$p$: Period of time for which the simulation has effectively run~~

~~$P_c$: Average RF power available per beam (cell)~~

~~$P_d$: S-band RF power available per user~~

~~$P_G$: Aggregate power at the input of the FSS feeder transponder from a given grid~~

~~$P_S$: RF band power available per satellite~~

~~$R_b$: User channel information data rate (b/s)~~

~~$R_G$: Number of RLANs transmitting in the 5 150-5 250 MHz band within a given grid~~

~~$S_p$: Population within a grid~~

~~$t$: Total period (t) of time in which the interference threshold is exceeded~~

~~$T$: Number of CDMA carriers in beam (cell)~~

~~$T_e$: Noise temperature user terminal~~

~~$T_s$: Noise temperature satellite~~

~~$Z$: Number of cells in a satellite's footprint~~

### 5.1.2 Study 2 (Globalstar 5A/550, Document 5A/554 will be embedded as a separate file into RLAN sharing.)

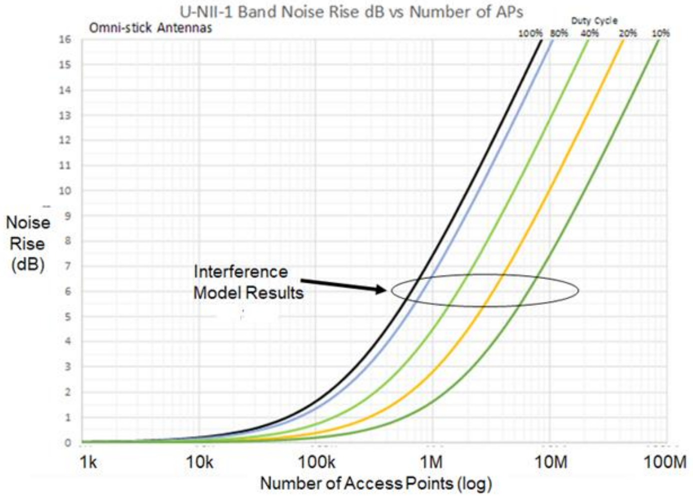
*[Editor's note: The information presented below from Document 5A/550 was not reviewed and agreed to by the meeting in November 2017 and appears in square brackets.]*

[In 2014, one Administration allowed potentially unlimited outdoor deployment of unlicensed RLAN access points on frequencies included in IEEE 802.11ac channels in the 5 170-5 250 MHz range which overlaps the FSS 5 096-5 250 MHz feeder uplink of the LEO-D Mobile Satellite Service (MSS) system. Since that time, despite the restrictions imposed by this Administration, for the purpose of limiting the emissions from access points, LEO-D has observed a rising noise floor in the feeder uplink as measured by satellites over the territory of that Administration. LEO-D attributes this noise rise to the aggregated interference of outdoor RLAN access points deployed in the frequency band 5 170-5 250 MHz.

A ~~s~~tatic model of the aggregate interference from outdoor RLANs distributed uniformly within the coverage area of the LEO-D satellite, elaborated in Document 5A/550, shows that the noise rise of 1.8 db in 5 170-5 250 MHz measured by satellites over the territory of that Administration is consistent with the deployment of 1 million outdoor access points that are compliant with the Administration rules of 4 watts EIRP, and operating at a busy hour duty cycle of 10%. The cable TV industry, one group deploying RLANs in the territory of that Administration., reports that 10 million total access points are using 5 170-5 250 MHz as of August of 2017, implying that as many as 10% of access points deployed may be operating outdoors. The static model also shows the variation in noise rise experienced in the LEO-D uplink as a function of the total number of outdoor RLANS deployed and their average duty cycle. Model results indicate that the same noise rise is also produced by 180 k outdoor access points operating at an average 40% duty cycle. This would imply that a smaller fraction of 1.8% of the total number of RLANs could also produce the same noise rise. This noise level increase is equivalent to an Interference-to-Noise ratio (I/N) of -3 db and is 9.2 dB higher than the value given in Recommendation ITU-R S.1432.

Document 5A/550 further presents an analysis of the relationship between noise rise in the MSS feeder uplink spectrum and degradation to the LEO-D MSS traffic-handling capacity and satellite RF power amplifier capacity. Based on the cable TV industry statements, the deployment of RLANs is increasing at a rate of 37% per year, and the Cisco Virtual Networking Index indicates that RLAN deployment is increasing as much as 43% per year in the next 5 years. If outdoor unlicensed RLAN deployments in 5 170-5 250 MHz in the territory of the Administration increase at the projected rates of 35-43% per year, LEO-D will suffer substantial degradation to its MSS traffic capacity and satellite power consumption. Since there is no method for limiting the number of RLAN deployments over geographic regions encompassing a 3901 km radius, the area within which outdoor RLANs in 5 170-5 250 MHz could cause aggregate interference to the MSS feeder uplink, modification of the current Radio Regulations and Recommendations prohibiting outdoor RLAN operation at 5 150-5 250 MHz could be ill advised.

The model in this report (Document 5A/550) assumes (1) access point characteristics and transmitted power levels that are consistent with the regulations of that Administration, (2) antenna gain characteristics representative of actual equipment in the field, and (3) LEO-D operating characteristics as described in filings with the Administration. This analysis also presents the effects of urban “clutter,” building shadowing, and different access point duty cycles on aggregate interference to the MSS feeder uplinks and the resulting detrimental impact on LEO-D MSS operations.




This figure shows the predicted rise in the noise floor of the LEO-D system as a result of the outdoor deployment of RLAN access points in the frequency range 5 170-5 250 MHz.]

### 5.1.3 Study 3 (Globalstar 5A/553)

#### 5.1.3.1 Interference Analysis

The interference situation set out in the previous section was analyzed using a computer simulation that was conducted using the Visualyse simulation tool that is available from Transfinite Systems (www.transfinite.com).

##### 5.1.3.1.1 Simulation Description

The use of the 5 GHz band by WAS/RLAN beyond what is contained in the current Radio Regulations was treated as part of WRC-2015 agenda item 1.1, and studies were conducted by Joint Task Group (JTG) 4-5-6-7 during the period between WRC-12 and WRC-15. The outcome of these studies is summarized in Reports from the JTG.

The technical requirements of WAS/RLANs in the 5 GHz frequency range have been captured in a subsequent document from ITU-R Working Party 5A, "Working document towards a preliminary draft new Report ITU-R M.[RLAN REQ-PAR] – *Technical characteristics and operational requirements of WAS/RLAN in the 5 GHz frequency range*; (Annex 27 to Document 5A/469). The RLAN parameters used in this study are derived from that document, including RLAN bandwidth and e.i.r.p. distributions and deployment densities.

The assumption was made that interference from WAS/RLAN would be primarily from RLANs rather than from WAS. The WAS/RLAN parameters provided below are based upon this assumption. As there are potentially millions of RLANs in the 5 150-5 250 MHz band, it is impossible to simulate each RLAN as an individual interferer. Hence, the power from the individual RLANs has been aggregated and this aggregation has been used as the output power from a single terrestrial "pseudo-station" (see Section 5.1.3.4.1.1). This technique is consistent with the "reference System" approach that is used to simulate interference involving terrestrial cellular telephone systems.

[Editor's Note: Further investigation of the effect of pseudo-stations is required.]

[The computer simulation focused on the European region since it has a large population of RLANs and the area easily falls within the footprint of the MSS spacecraft antenna. For the purpose of the simulation it was assumed that Europe consists only of the most populous 45 European countries. A separate terrestrial pseudo-station was established to represent the total number of RLANs deployed in both urban and rural areas. There were, thus, a total of 85 different terrestrial stations, 45 urban and 40 rural, established for the simulation. The coordinates for the pseudo-stations were those of the capital of the country for urban stations, and a rural location for the rural pseudo-stations. A list of these cities, their coordinates, and the respective populations of the countries are shown in Appendix 1.]

#### 5.1.3.1.1.1 Clutter Loss

In this version of the simulation, the effects of clutter and building entry loss were taken into account by combining these losses with the antenna pattern. The clutter loss was based on the method given in Recommendation ITU-R P.2108, noting the recent advice in Document 5A/499 from Working Parties 3K and 3M.

One form of the interference calculation equation in dB is:

$$I = P_{tx} + G_{tx} - L_{path} - L_{clutter} + G_{rx}$$

In absolute / linear representation, this is (using lower case to represent linear / absolute values):

$$i = \frac{p_{tx} g_{tx} g_{rx}}{l_{path} l_{clutter}}$$

Interference aggregation should be done using power summation (i.e., in the linear or absolute domain), and hence the equation for aggregate interference from $N$ transmitters is:

$$i_{agg} = \sum_{k=1}^{N} i_k = \sum_{k=1}^{N} \frac{p_{tx,k} g_{tx,k} g_{rx,k}}{l_{path,k} l_{clutter,k}}$$

If the power, gains and path loss are the same for each of the $N$ transmitters then this is simplified to:

$$i_{agg} = \frac{p_{tx} g_{tx} g_{rx}}{l_{path}} \sum_{k=1}^{N} \frac{1}{l_{clutter,k}}$$

The average of the inverse of the clutter loss is:

$$\frac{1}{l_{clutter,avg}} = \frac{1}{N} \sum_{k=1}^{N} \frac{1}{l_{clutter,k}}$$

Thus:

$$l_{clutter,avg} = \frac{N}{\sum_{k=1}^{N} \frac{1}{l_{clutter,k}}}$$

This is the average over the sample. As the number of transmitters increases this will tend towards the average over the population. Hence for large numbers it is acceptable to use the average over the population as representative of the average of the sample.

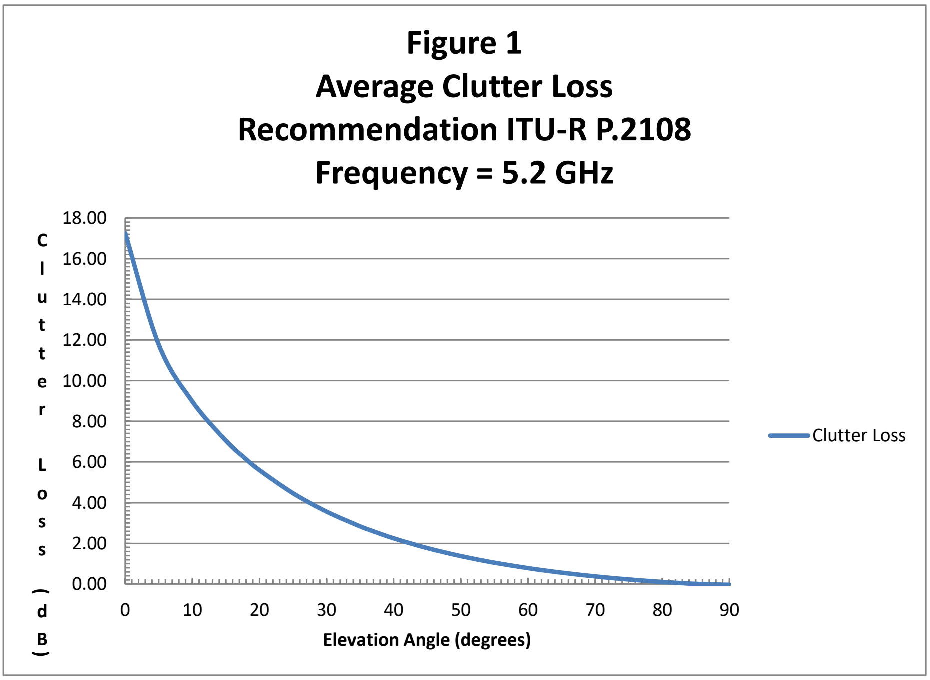
The aggregate interference from N transmitters is then:

$$i_{agg} = \frac{p_{tx} g_{tx} g_{rx}}{l_{path}} \cdot \frac{N}{l_{clutter,avg}}$$

In dB this is:

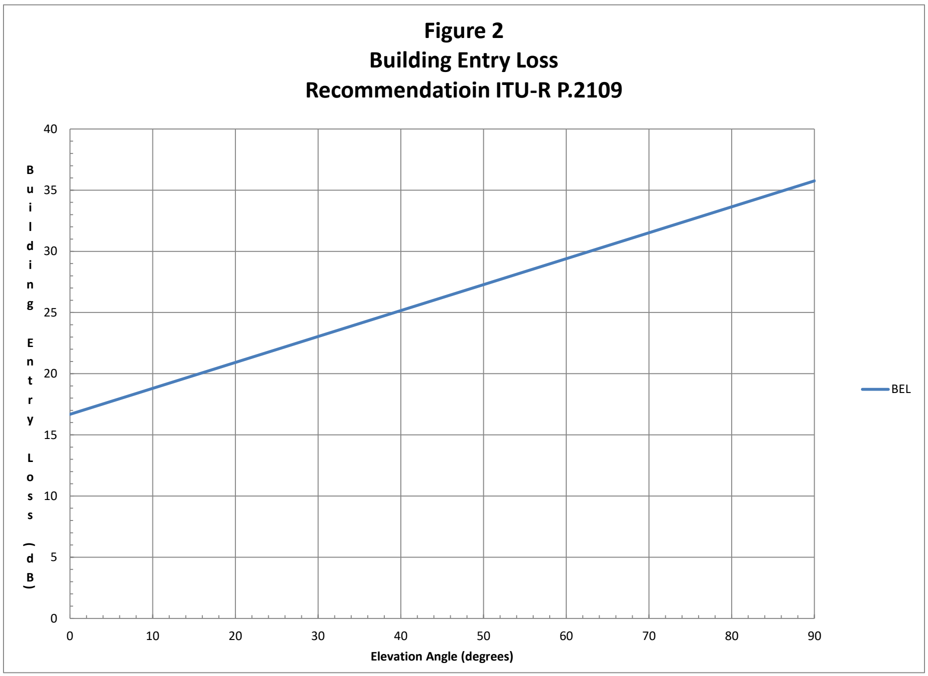
$$I_{agg} = P_{tx} + G_{tx} - L_{path} - L_{clutter,avg} + G_{rx} + 10 log_{10} N$$

A plot of the average clutter loss versus elevation angle from the horizontal is shown in Figure 1.




#### 5.1.3.1.1.2 Building Entry Loss

The building entry loss (BEL) was computed based on the guidance provided in Recommendation ITU-R P.2109. The median building entry loss was used for all indoor RLANs. A plot of the building entry loss (BEL) is shown in Figure 2.




#### 5.1.3.1.1.3 RLAN Transmitter Power

The power output for each pseudo-station that simulates either the urban or rural population of WAS/RLAN devices is determined using the average RLAN power output and the RLAN density per inhabitant (given in the next section) multiplied by the number of inhabitants of each country that live in either the urban or rural portion of that country. Population data was obtained from data on the Internet (see www.worldometers.info/population/countries-in-europe-by-population.

#### 5.1.3.1.2 WAS/RLAN Parameters

The parameters of WAS/RLANs used in the computer simulation were based on Annex 27 to Document 5A/469. As mentioned in the previous section, the parameters chosen for the RLAN transmitters are consistent with those given in Section 3 of Annex 27 of 5A/469.

[Editor's Note: Further discussion on the text below is needed at next meeting.]

Under the current Radio Regulations, restricting RLAN deployment to indoors, the e.i.r.p. distribution given in Annex 27 yields an average e.i.r.p. of -11 dBW. One Administration has suggested that RLAN transmitters be authorized to use an e.i.r.p. of +6 dBW. Substituting this high power RLAN transmitter for the currently authorized 200 mW (-7 dBW) transmitter changes the average e.i.r.p. Simulations involving outdoor RLAN transmitters assumed that the 200 mW transmitters shown in TABLE 2A of 5A/469 (Annex 27) were replaced by higher power, outdoor deployed transmitters. Since the outdoor deployment percentages were lower than 19%, a smaller percentage of 200 mW transmitters was retained in the distribution of transmitters and the computation of the average e.i.r.p.. This smaller percentage was equal to the difference between 19% and the percentage of outdoor deployed RLAN transmitters.

Two different RLAN antenna patterns were used in the simulation. For indoor RLAN transmitters, an omni-directional pattern with a gain of -2 dBi in all directions was used. This type of antenna is referenced in section 3.5 of Document 5A/469 (Annex 27). For the outdoor RLAN transmitters with 6 dBW e.i.r.p., the antenna pattern shown in Figure 3 below was used. This pattern is derived from commercially available omni-directional antennas with 6 dBi gain.

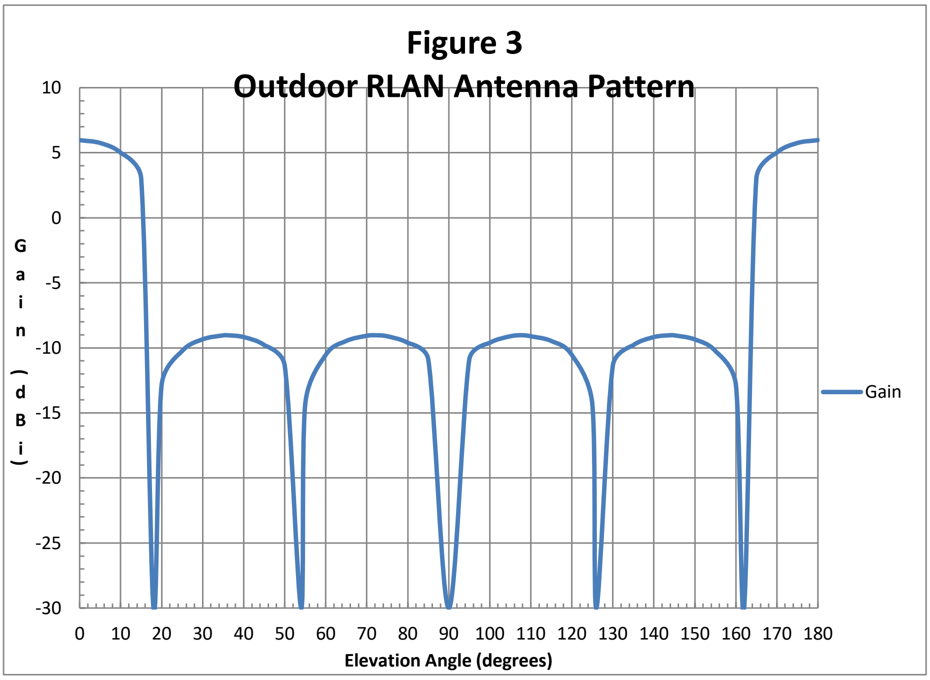



**Figure 3**
**Outdoor RLAN Antenna Pattern**

For the simulation presented here, the pertinent factors are summarized:

| Case under study | Receiver Bandwidth (MHz) | Overlapping Factor | Resulting density (RLAN/inhab.) | Average Bandwidth Factor |
|---|---|---|---|---|
| MSS Feeder Links | 19.38 | 14.0% | 0.0038 | 6.06 dB |

Detailed calculations of the overlapping factors and average bandwidth factors are given in the following file.

Nb of RLAN and
overlap 5 GHz (MSS)

The parameters given assume that RLANs are distributed over the entire 5 150–5 350 MHz and 5 470-5 925 MHz ranges and would have to be recalculated should this overall range change.

### 5.1.3.1.3 FSS Feeder link parameters

As mentioned above, the parameters of the feeder uplinks of the LEO-D MSS system were used in the computer simulation. These are summarized in the Table below.

TABLE 2

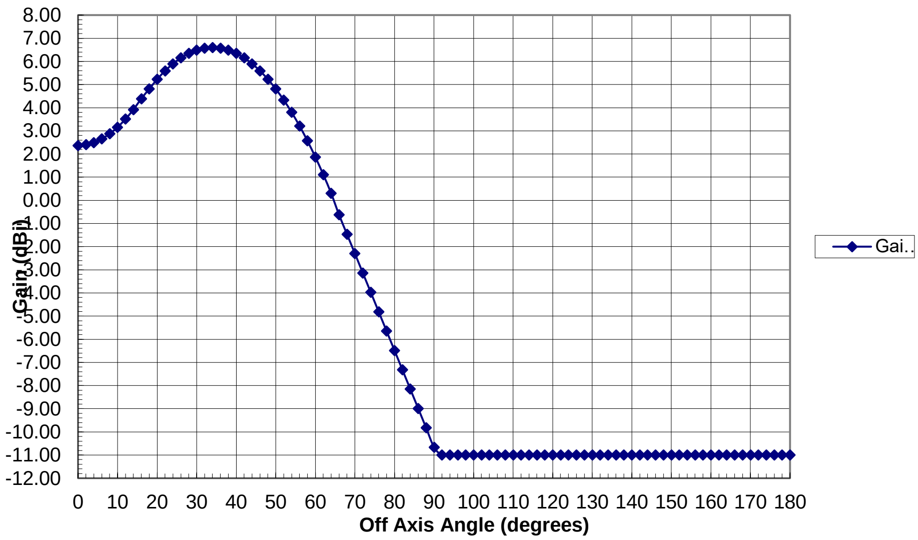
**MSS Feeder Link Parameters**

| Parameter | HIBLEO-4 FL |
|---|---|
| Satellite orbit altitude *h* (km) | 1 414 |
| Satellite Inclination (degrees) | 52 |
| Frequency Range (MHz) | 5 150-5 250 |
| Satellite receiver bandwidth *B* (MHz) | 16.5 |
| I/N (dB) | -12.2 |
| Satellite receiver noise temperature *T* (K) | 550 |
| $P_{noise,\ add}$ (dBW) | -140.3 |
| $I_{add}$ (dBW) | -152.5 |
| Polarization discrimination $L_p$ (dB) | 1 |

The spacecraft receive antenna is an “iso-flux” antenna and the gain pattern is shown below.

FIGURE 3

**Spacecraft Receive Antenna Pattern**




### 5.1.3.2 Computer simulation description

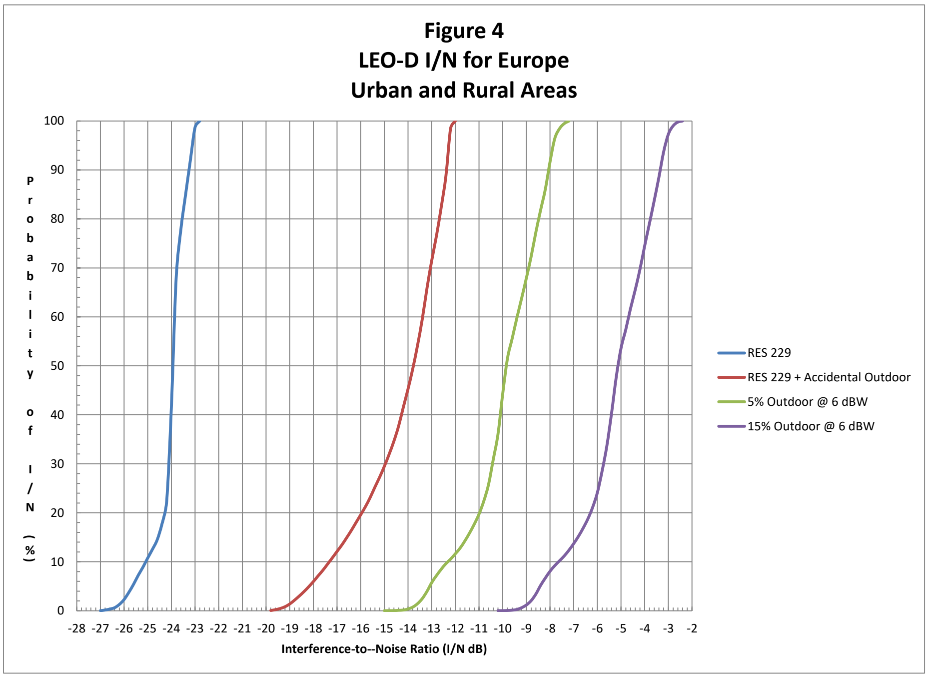
The simulation determined the level of interference that would be experienced by a feeder link carrier that was uplinked from the earth station in Aussaguel, France, near Toulouse. This uplink carrier was switched from one spacecraft to another based on whichever spacecraft was the closest to the earth station. The interference was recorded as an interference-to-noise ratio.

The simulation time step in this version of the simulation was 10 Seconds. A 10 Second interval implied that the area under the footprint changed by 0.139%. The simulation was run for two simulation days or 17 280 time steps. This simulated period approximates the ground track repeat for two successive orbital planes of the MSS system.

The antenna parameters included in the computer simulation include the antenna gain pattern and the clutter and building entry losses, where applicable.

### 5.1.3.3 Computer simulation results

The results of this simulation are shown in Figure 4. All of the results pertain to RLANs operating in Europe. RLANs from other nearby regions are not used in this simulation.




The graph shows the probability of interference for 4 different situations as a function of interference-to-noise ratio (I/N).

The leftmost plot in Figure 4 shows the potential interference that would be due to a strict adherence to Resolution **229** and does not include any outdoor RLAN transmitters.

The next plot to the right shows the potential interference expected if the current Resolution **229** is observed with an "accidental" 5% portion of the European RLANs being outdoors.

The next plot to the right shows the potential interference results for RLANs over Europe if 5% of the RLAN transmitters are operated outdoors with omni-directional antennas with 6 dBi gain, pointed at the horizon, and an e.i.r.p. of 6 dBW. RLAN transmitters complying with these characteristics have been proposed by one Administration.

The right most plot shows the potential interference results for RLANs over Europe if 15% of the RLAN transmitters are operated outdoors with omni-directional antennas with 6 dBi gain, pointed at the horizon, and an e.i.r.p. of 6 dBW. This percentage of outdoor operation has been proposed by another Administration.

These simulations assume clutter loss for RLANs operating in urban areas and indoor RLANs include building entry loss (BEL). These losses were explained in Section 5.1.4.1, above. It is assumed that there is no clutter loss in rural areas.

It is worthwhile to note that interference from European RLANs operating at 6 dBW e.i.r.p. will exceed an I/N = -12.2 dB threshold at least 90% of the time.

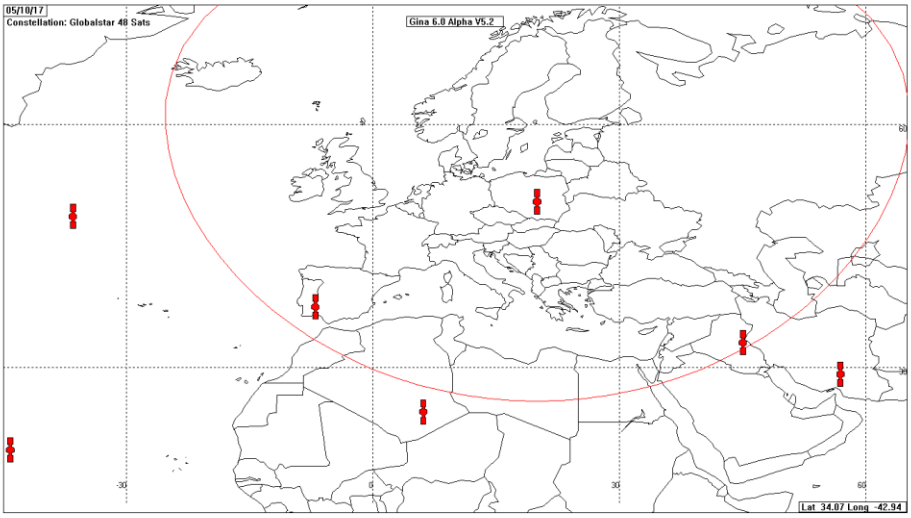
### 5.1.3.4 Summary and Assessment of Sharing Feasibility

Computer simulation of the likely effect of outdoor RLAN transmitters has shown that significant interference would be caused to the feeder uplinks of MSS systems. Figure 5 shows the “footprint” of the feeder uplink antenna of the LEO-D system. It is apparent that the spacecraft will “see” all of the RLAN traffic in the European region.

The level of interference to feeder uplinks from co-band 5 GHz RLANs will depend on the total number of RLAN devices that are deployed, their e.i.r.p., and whether they are permitted to operate outdoors.

FIGURE 5

**LEO-D MSS System European Feeder Uplink Coverage**




The simulations presented here indicate that there will be unacceptable interference to the feeder uplinks of MSS systems using the 5 150-5 250 MHz band. The projected interference levels from outdoor deployment exceed the industry guideline of -12.2 dB I/N by at least 2 dB, with 50% probability. Mitigation techniques may be devised and implemented, but it is likely that the proliferation of these devices will, at some time, exceed the capabilities of these techniques and result in unacceptable interference to MSS feeder uplinks. At that time, the only recourse left will be to stop the outdoor deployment of access points.

If no records of the deployment of outdoor access points are maintained by Administrations, there will be no way to determine where the interference to the feeder uplinks is emanating from and no way to limit such interfering operations.

The use of outdoor access points would require Administrations to maintain records of deployment so that when interference occurs, remedial action can be taken by the correct Administration. Without a database of deployments, quantitative limits for outdoor deployed access points will be required at the outset.

~~Given the results of this study, it appears that the best way of ensuring reasonable ongoing protection of the worldwide non-GSO MSS feeder uplinks is to make no change in the provisions of Resolution **229 (Rev.WRC-12)** regarding the 5 150-5 250 MHz band.~~

# APPENDIX 1

## Locations of "Pseudo-Stations"

5 GHz Stations for WP 5A Simulation

| | Country Power | City | Latitude | Longitude | Population | |
|---|---|---|---|---|---|---|
| | =========== | =========== | ======== | ======== | ========= | ======== |
| | Albania | | | | | |
| 1 | U | Tirana | 41.317 | 19.817 | 1872048 | |
| 2 | R | Lushnje | 40.851 | 19.782 | 1039380 | |
| | Andorra | | | | | |
| 3 | | Andorra la V | 42.5 | 1.52 | 68728 | |
| | Austria | | | | | |
| 4 | U | Vienna | 48.2 | 16.37 | 5670984 | |
| 5 | R | Wels | 48.05 | 14 | 2921416 | |
| | Belarus | | | | | |
| 6 | U | Minsk | 53.9 | 27.57 | 7093901 | |
| 7 | R | Slonim | 53.08 | 25.32 | 2364634 | |
| | Belgium | | | | | |
| 8 | U | Brussels | 50.85 | 4.35 | 10986077 | |
| 9 | R | Leopoldsburg | 51.11 | 5.25 | 457753 | |
| | Bos&Herz | | | | | |
| 10 | U | Sarajevo | 43.866 | 18.417 | 1524689 | |
| 11 | R | Sanski Most | 44.717 | 16.667 | 2268070 | |
| | Bulgaria | | | | | |
| 12 | U | Sofia | 41.683 | 23.317 | 5241673 | |
| 13 | R | Yambol | 49.483 | 26.467 | 1803586 | |
| | Crotia | | | | | |
| 14 | U | Zagreb | 45.8 | 16 | 2513260 | |
| 15 | R | Sisak | 45.48 | 16.4 | 1696555 | |

| | | | | | |
|---|---|---|---|---|---|
| | Cyprus | | | | |
| 16 | | Nicosia | 35.16 | 33.367 | 794646 |
| 17 | | Galateia | 35.4222 | 34.0722 | 394944 |
| | Czech Rep | | | | |
| 18 | U | Prague | 50.083 | 14.467 | 7895237 |
| 19 | R | Brno | 49.1 | 16.55 | 2659893 |
| | Denmark | | | | |
| 20 | U | Copenhagen | 55.717 | 12.567 | 4992146 |
| 21 | R | Hovborg | 55.6069 | 8.9411 | 719691 |
| | Estonia | | | | |
| 22 | U | Talinn | 59.417 | 24.75 | 861798 |
| 23 | R | Rapla | 58.994 | 24.801 | 443957 |
| | Finland | | | | |
| 24 | U | Helsinki | 60.166 | 24.933 | 4621423 |
| 25 | R | Oulu | 60.067 | 25.467 | 919851 |
| | France | | | | |
| 26 | U | Paris | 48.857 | 2.351 | 52080850 |
| 27 | R | Guingamp | 48.583 | 3.15 | 12857866 |
| | Germany | | | | |
| 28 | U | Berlin | 52.517 | 13.383 | 62251088 |
| 29 | R | Bremervoerde | 53.483 | 9.133 | 18385036 |
| | Greece | | | | |
| 30 | U | Athens | 37.967 | 23.717 | 8714345 |
| 31 | R | Sofades | 39.333 | 22.1 | 2178586 |
| | Hungary | | | | |
| 32 | U | Budapest | 47.433 | 19.25 | 7086443 |
| 33 | R | Svarvas | 46.864 | 20.557 | 2701462 |
| | Iceland | | | | |
| 34 | U | Reykjavik | 64.133 | 21.933 | 320597 |
| 35 | R | Hella | 63.833 | 20.4 | 13706 |
| | Ireland | | | | |
| 36 | U | Dublin | 53.344 | 353.732 | 3034709 |
| 37 | R | Mullingar | 53.523 | 352.662 | 1714444 |

| | | | | | |
|---|---|---|---|---|---|
| | Italy | | | | |
| 38 | U | Milan | 45.467 | 9.183 | 42277170 |
| 39 | R | Volterra | 43.4 | 10.867 | 17520808 |
| | Lativa | | | | |
| 40 | U | Riga | 56.95 | 24.1 | 1361196 |
| 41 | R | Pope | 57.4 | 21.852 | 583370 |
| | Liechtenstein | | | | |
| 42 | | Vaduz | 47.167 | 9.51 | 38022 |
| | Lithuania | | | | |
| 43 | U | Vilnius | 54.683 | 25.317 | 1987069 |
| 44 | R | Kretinga | 55.89 | 21.242 | 843513 |
| | Luxembourg | | | | |
| 45 | U | Luxembourg | 49.6 | 6.117 | 497072 |
| 46 | R | Betzdorf | 49.6875 | 6.35 | 87031 |
| | Macedonia | | | | |
| 47 | U | Skopje | 42 | 21.433 | 1623115 |
| 48 | R | Dolneni | 41.425 | 21.454 | 1180193 |
| | Malta | | | | |
| 49 | | Valletta | 35.9 | 14.517 | 420521 |
| | Moldova | | | | |
| 50 | U | Chisinau | 47 | 28.917 | 1540763 |
| 51 | R | Floresti | 47.893 | 28.301 | 2513877 |
| | Monaco | | | | |
| 52 | U | Monte Carlo | 43.733 | 7.417 | 38010 |
| | Montenegro | | | | |
| 53 | U | Podgorica | 42.783 | 19.467 | 398921 |
| 54 | R | Golubuvci | 42.334 | 19.225 | 227329 |
| | Netherlands | | | | |
| 55 | U | Amsterdam | 52.367 | 4.883 | 15363626 |
| 56 | R | De Koog | 53.098 | 4.763 | 1669219 |
| | Norway | | | | |
| 57 | U | Oslo | 59.933 | 10.683 | 4195340 |
| 58 | R | Froeya | 63.726 | 8.744 | 1135460 |

| | | | | | |
|---|---|---|---|---|---|
| | Poland | | | | |
| 59 | U | Warsaw | 52.217 | 21.033 | 23138144 |
| 60 | R | Wolsztyn | 52.117 | 16.117 | 15425429 |
| | Portugal | | | | |
| 61 | U | Lisbon | 38.767 | 350.85 | 6795296 |
| 62 | R | Coruche | 38.957 | 351.473 | 3469501 |
| | Romania | | | | |
| 63 | U | Bucharest | 44.417 | 26.1 | 11773357 |
| 64 | R | Faurei | 45.0842 | 27.2728 | 7641155 |
| | Russian Fed | | | | |
| 65 | U | Moscow | 55.75 | 37.617 | 80520000 |
| 66 | R | Kizhi | 62.0667 | 35.2381 | 29480000 |
| | San Marino | | | | |
| 67 | U | San Marino | 45.9417 | 12.4583 | 32104 |
| | Serbia | | | | |
| 68 | U | Belgrade | 44.8 | 20.467 | 5222279 |
| 69 | R | Opovo | 45.0519 | 20.4303 | 3554661 |
| | Slovakia | | | | |
| 70 | U | Bratislava | 48.15 | 17.117 | 2922500 |
| 71 | R | Surovce | 48.3329 | 17.7174 | 2509657 |
| | Slovenia | | | | |
| 72 | U | Ljubljana | 46.05 | 14.5 | 1033555 |
| 73 | R | Brezice | 45.904 | 15.5922 | 1037697 |
| | Spain | | | | |
| 74 | U | Madrid | 40.433 | 356.3 | 37777519 |
| 75 | R | Carmona | 37.467 | 5.633 | 8292626 |
| | Sweden | | | | |
| 76 | U | Stockholm | 59.35 | 18.067 | 8392848 |
| 77 | R | Torup | 56.958 | 13.081 | 1527776 |
| | Switzerland | | | | |
| 78 | U | Bern | 46.95 | 7.45 | 6154572 |
| 79 | R | Gland | 46.42 | 6.27 | 2299511 |
| | Turkey | | | | |
| 80 | U | Ankara | 39.917 | 32.833 | 58247209 |

| | | | | | |
|---|---|---|---|---|---|
| 81 | R | Yumurtalik | 36.769 | 35.797 | 22316012 |
| | Ukraine | | | | |
| 82 | U | Kiev | 50.45 | 30.5 | 30994725 |
| 83 | R | Vysokopillia | 47.488 | 33.532 | 13410330 |
| | U.K. | | | | |
| 84 | U | London | 51.5 | 0 | 53784611 |
| 85 | R | Mullaig | 57.004 | 354.173 | 11726486 |

APPENDIX 2

# Sample Link for 5% Outdoor Deployment of 6 dBW RLAN Transmitters

| | | |
|---|---|---|
| Link Calculation | | |
| Transmit Station | | Aussaguel |
| | Antenna | Antenna |
| Transmit Frequency | | 5.192-5.208 GHz |
| | Centre | 5.200 GHz |
| | Bandwidth | 16.5 MHz |
| Transmit Power | | -4.7 dBW |
| | EIRP | 42.030 dBW |
| Transmit Gain | | 46.730 dB |
| | Relative Gain | 0.0 dB |
| | Peak Gain | 46.73 dBi |
| Path Loss | | 171.121491 dB |
| | ITU-R Rec. P.525 | 171.070562 dB |
| | ITU-R Rec. P.618 | 0.000331 dB |
| | ITU-R Rec. P.676 (dry) | 0.046746 dB |
| | ITU-R Rec. P.676 (water) | 0.003852 dB |
| Receive Station | | GstarSats-40 |
| | Antenna | Antenna |
| Receive Gain | | 5.645 dB |
| | Relative Gain | 4.134738 dB |
| | Peak Gain | 1.51 dBi |
| N (receive noise) | | -129.021365 dBW |
| | Noise Temperature | 550.0 K |
| | Wanted Bandwidth | 16.5 MHz |
| | Noise/Hz | -201.196205 dBW/Hz |
| C (signal strength) | | -126.346753 dBW |
| | Margin | 23.653247 dBW |
| | Threshold | -150.0 dBW |
| C/N | | 2.674612 dB |
| | Margin | -7.325388 dB |

| | | |
|---|---|---|
| | Threshold | 10.0 dB |
| Worst Interferer | | |
| Station | | 74 Madrid |
| | Antenna | Antenna1 |
| Interferer Bandwidth | | 16.5 MHz |
| Interferer Power | | 32.5 dBW |
| | EIRP | 22.967 dBW |
| Interferer Gain | | -9.533 dB |
| | Relative Gain | 1.756608 dB |
| | Peak Gain | -11.29 dBi |
| Path Loss | | 170.686701 dB |
| | ITU-R Rec. P.525 | 170.639036 dB |
| | ITU-R Rec. P.618 | 0.000103 dB |
| | ITU-R Rec. P.676 (dry) | 0.044865 dB |
| | ITU-R Rec. P.676 (water) | 0.002696 dB |
| Wanted Gain | | 5.131 dB |
| | Relative Gain | 3.62144 dB |
| | Peak Gain | 1.51 dBi |
| | Wanted Feeder Loss | 2.9 dB |
| Wanted Bandwidth | | 16.5 MHz |
| Signal Strength | | -145.488653 dBW |
| Bandwidth Advantage | | 0.0 dB |
| Polarisation Advantage | | 1.46128 dB |
| Frequency Adjustments | | 0.0 dB |
| Other Advantages | | 0.0 dB |
| I | | -146.949933 dBW |
| C/I | | 20.60318 dB |
| | Margin | -4.39682 dB |
| | Threshold | 25.0 dB |
| C/(N+I) | | 2.605197 dB |
| | Margin | -22.394803 dB |
| | Threshold | 25.0 dB |
| I/N | | -17.928568 dB |
| | Margin | 2.728568 dB |
| | Threshold | -20.657135 dB |
| Aggregate Interference | | |
| Number of Interferers | | 167 |
| I | | -139.683814 dBW |
| C/I | | 13.337061 dB |
| | Margin | -11.662939 dB |
| | Threshold | 25.0 dB |
| C/(N+I) | | 2.316902 dB |
| | Margin | -22.683098 dB |
| | Threshold | 25.0 dB |
| I/N | | -10.662449 dB |

| | |
|---|---|
| Margin | -4.537551 dB |
| Threshold | -6.124897 dB |

### 5.1.4 Study 4 (CHN 5A/574)

*[**Editor's note:** The information of COMPASS-MSS system in this study needs confirmation from WP 4A.]*

*[**Editor's note:** Further studies are needed for the percentage of outdoor RLAN.]*

This document provides a preliminary analysis of interference from potential outdoor WAS/RLAN applications with the feeder uplinks of the COMPASS-MSS system in the fixed-satellite service (FSS) in the frequency band 5 150-5 250 MHz.

#### 5.1.4.1 Technical characteristics

##### 5.1.4.1.1 Technical and operational characteristics of WAS/RLAN system operating in the 5 150-5 250 MHz frequency band

The parameters of WAS/RLAN used in the analysis are based on "Working document towards a preliminary draft new Report ITU-R M.[RLAN REQ-PAR] – *Technical characteristics and operational requirements of WAS/RLAN in the 5 GHz frequency range*; (Annex 27 to Document 5A/469). These parameters are summarized in the Table 1 below.

TABLE 1

**WAS/RLAN Parameters**

| Parameter | Value |
|---|---|
| Average RLAN e.i.r.p. (dBm) | 19[29] |
| Average Antenna Discrimination in Elevation (dB) | 2 |
| Average RLAN Device Density (active devices per inhabitant) | 0.0265 |

Besides the parameters in the Table 1, WAS/RLAN overlapping factors and average bandwidth factors are given in the working document for satellite service, as showed in the Table 2 below.

TABLE 2

**WAS/RLAN Overlapping Factors and Average Bandwidth Factors regarding satellite services**

| Case under study | Receiver Bandwidth (MHz) | Overlapping factor | Resulting density (RLAN/inhab.) | Average Bandwidth factor |
|---|---|---|---|---|
| FSS | 40 | 12.9 % | 0.0034 | 3.59 dB |
| EESS (SAR) | 100 | 22 % | 0.0058 | 1.94 dB |
| EESS (Altimeter) | 320 | 48.9 % | 0.0130 | 0.35 dB |

[29] This figure comes from the Excel table embedded in section 3.6 of the Working document towards a preliminary draft new Report ITU-R M.[RLAN REQ-PAR] and needs to be further reviewed after the working document has been finalized.

| Case under study | Receiver Bandwidth (MHz) | Overlapping factor | Resulting density (RLAN/inhab.) | Average Bandwidth factor |
|---|---|---|---|---|
| EESS (scatterometer) | 2 | 11.0 % | 0.0029 | 15.89 dB |
| MSS Feeder links | 16.5 | 11.0 % | 0.0029 | 6.73 dB |

For the case of COMPASS-MSS system, the satellite receiver bandwidth is 8.2 MHz, which is not included in the table. Following the calculation method in the working document, the overlapping factor and average bandwidth factor of the COMPASS-MSS system can be derived, as showed in the Table 3 below.

TABLE 3

**WAS/RLAN Overlapping Factors and Average Bandwidth Factors regarding COMPASS-MSS system**

| Case under study | Receiver Bandwidth (MHz) | Overlapping factor | Resulting density (RLAN/inhab.) | Average Bandwidth factor |
|---|---|---|---|---|
| COMPASS-MSS system | 8.2 | 11.0 % | 0.0029 | 9.77 dB |

#### 5.1.4.1.2 Technical and operational characteristics of FSS system operating in the 5 150-5 250 MHz frequency band

China is planning to deploy a MSS system, i.e. next generation COMPASS-MSS system, with the service link of 1.6/2.5 GHz bands. This system will include several IGSO satellites, which plan to utilize inclined-orbit spacecrafts at an altitude of 36 000 kilometers and an inclination angle of the orbits of about 55 degrees. The feeder uplink of the IGSO satellites will operate in 5 091-5 250 MHz frequency band.

The parameters of the feeder uplink of the COMPASS-MSS system are summarized in the Table below.

TABLE 4

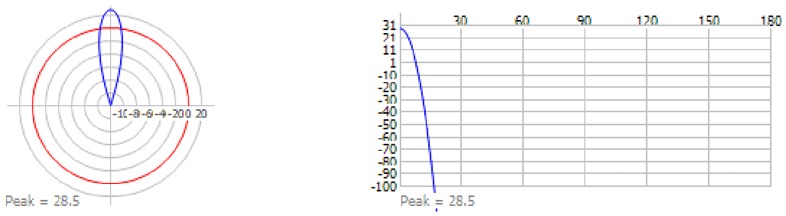
**COMPASS-MSS Feeder Uplink Parameters**

| Parameter | COMPASS-MSS system |
|---|---|
| Satellite orbit altitude *h* (km) | 36 000 |
| Satellite Inclination (degrees) | 55 |
| Frequency Range (MHz) | 5 091-5 250 |
| Satellite receiver bandwidth *B* (MHz) | 8.2 |
| I/N (dB) | -12.2* |
| Satellite receiver noise temperature *T* (K) | 500 |
| $P_{noise,\ add}$ (dBW) | -130.5 |
| $I_{add}$ (dBW) | -142.7 |
| Polarization discrimination $L_p$ (dB) | 1 |
| *The protection cretiria is being investegated in WP 4A. | |

The spacecraft receive antenna is an “iso-flux” antenna and the gain pattern is shown below.

FIGURE 1

**Spacecraft Receive Antenna Pattern**




### 5.1.4.2 Methodology

#### 5.1.4.2.1 Interference Analysis scenario

Due to the Earth-coverage beam, the satellite can receive emissions from very large numbers of WAS/RLAN transmitters.

The assumption was made that interference from WAS/RLAN would be primarily from RLANs and more specifically from access points in RLAN systems. As there are potentially millions of RLAN access points in the 5 150-5 250 MHz band, it is difficult to simulate each access point as an individual interferer. Hence, the power from the individual access points has been aggregated and this aggregation has been used as the output power from a single terrestrial station.

The area within the red dashed line of Figure 2 shows the “footprint” of the feeder uplink which is uplinked from the earth station located in Hainan, China. It can be found that most counties of South-Eastern Asia and Southern China are within the footprint of the satellite.

FIGURE 2

**Footprint of the Feeder Uplink Antenna of the COMPASS-MSS System**

For the simulation it is assumed that there is one terrestrial station (aggregated station) in each country/region of the footprint area. The countries/region and their populations are listed in the Table below (see http://www.worldometers.info/world-population/south-eastern-asia-population).

TABLE 5

**Countries/Region in the simulation and their populations**

| Country/Region | Population |
|---|---|
| Indonesia | 263,991,379 |
| Philippines | 104,918,090 |
| Viet Nam | 95,540,800 |
| Thailand | 69,037,513 |
| Myanmar | 53,370,609 |
| Malaysia | 31,624,264 |
| Cambodia | 16,005,373 |
| Laos | 6,858,160 |
| Singapore | 5,708,844 |
| Brunei Darussalam | 428,697 |
| Southern China | 500,000,000* |

* This figure is an approximate value based on that this region is one of the most densely populated areas in China.

#### 5.1.4.2.2 Calculations

The interference power for each RLAN terrestrial station (aggregated station) at the COMPASS-MSS system satellite receiver is calculated by equation (1) as below.

$$I_n = EIRP_{ave} + 10\log N_n - L_{Dis} - BWF - L_{pol} - L_{prop} + G_r(\theta) \qquad (1)$$

where:

$I_n$: Interference power from the n-th terrestrial station, dBm;

$EIRP_{ave}$ : Average e.i.r.p. of RLAN access points, 19dBm;

$N_n$: Number of RLAN access points in the n-th country/region;

$L_{Dis}$: Average RLAN Antenna Discrimination in Elevation, 2dB;

$BWF$: Average Bandwidth Factor, 9.77dB;

$L_{pol}$: Polarization discrimination, 1dB;

$L_{prop}$: Propagation loss including free space transmission loss, atmospheric loss (Rec. ITU-R P.676) and clutter loss (Rec. ITU-R P.2108), dB;

$G_r(\theta)$: Antenna gain of the satellite receiver in the direction of the n-th terrestrial station, dBi;

$\theta$: Off-axis angle, deg.

The number of RLAN access points in the n-th country/region $N_n$ is calculated by equation (2) as below.

$$N_n = Ds * P_n \qquad (2)$$

where:

$Ds$: Average RLAN device density, taking into account the overlapping factor, 0.0029 RLAN/inhab;

$P_n$: Population of the n-th country/region, population data is obtained from Table 5.

The aggregate interference is calculated by equation (3) as follows.

$$I_{total} = 10\log\left(\sum_{n=1}^{n=N} 10^{I_n/10}\right) \qquad (3)$$

where:

$I_{total}$: Received aggregate interference from all RLAN terrestrial stations (aggregated stations) inside footprint size, dBm;

$n$: Index of the RLAN terrestrial station;

$I_n$: Interference power from the n-th terrestrial station, dBm.

### 5.1.4.3 Interference Analysis

#### 5.1.4.3.1 Simulation Description

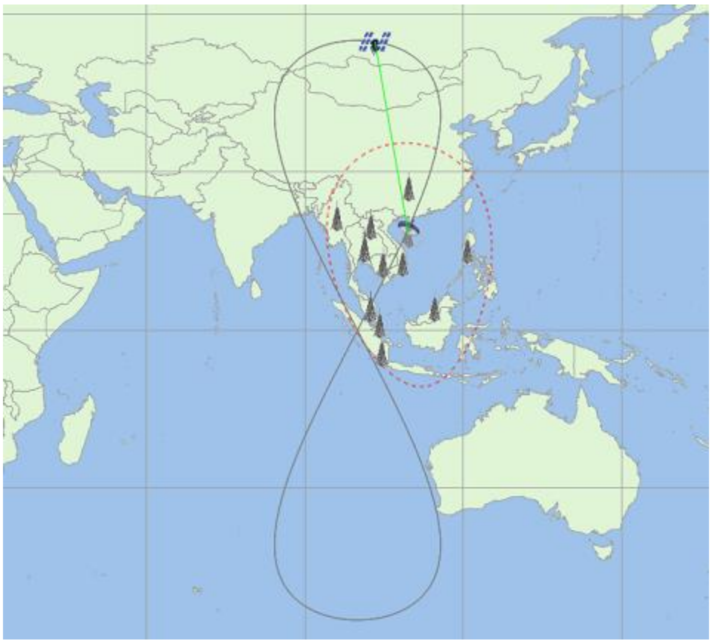
The analysis of the interference situation was conducted using the Visualyse simulation tool.

The simulation time step was 300 Seconds. The simulation was run for two simulation days or 576 time steps. This simulated time approximates two orbital periods of the IGSO satellite.

The simulation scenario is shown below.

FIGURE 3

**Simulation scenario**

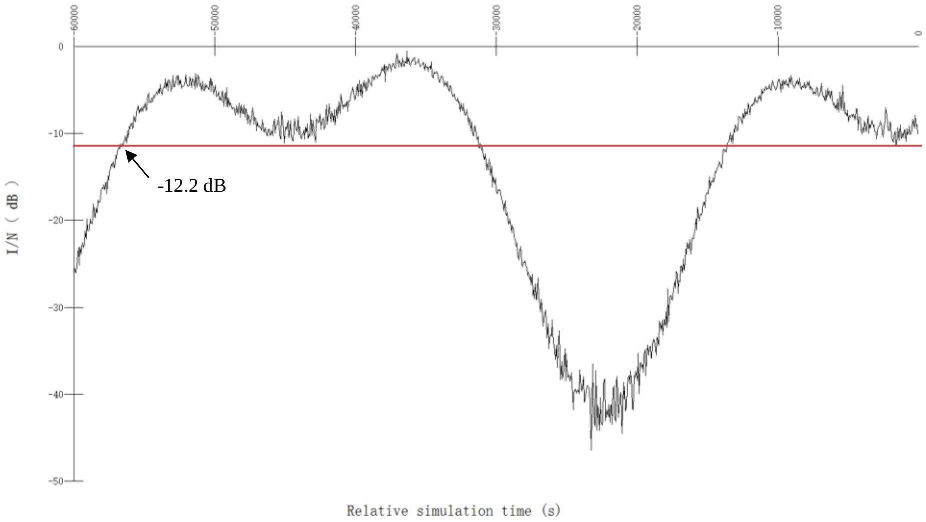


#### 5.1.4.3.2 Simulation results

The results of the simulation are shown in Figure 4 for one and a half simulation periods (days). It can be seen that the interference to the COMPASS-MSS system feeder link from RLAN access points will exceed the I/N = -12.2 dB threshold for over half of a simulation period. That means the COMPASS-MSS system feeder link will suffer interference from RLAN access points for more than 50% of the time.

FIGURE 4

**Results of the preliminary simulation**




### 5.1.4.4 Summary

The level of interference to FSS from RLANs in the frequency band 5 150-5 250 MHz will depend on many factors such as the total number of RLAN devices that are deployed, their e.i.r.p. and whether they are permitted to operate outdoors. This contribution concentrated on interference due to outdoor RLAN applications and has computed the potential interference due to those devices.

The level of the potential interference can be limited by limiting the total number of RLAN devices that are deployed, the e.i.r.p. of the access points above a given elevation angle, the number of outdoor deployed access points, etc.

### 5.1.5 Study 5 (JPN 5A/586)

Another example of a sharing study with realistic conditions is conducted as follows.

The parameters and protection criteria of the non-GSO MSS feeder links are assumed to be the same as described in section 4.1 (proposed in Document 5A/395) and additional conditions are assumed to be shown in Table A1:

TABLE A1

**Additional conditions for a sharing study with MSS feeder links**

| Parameters | Values and conditions |
|---|---|
| e.i.r.p. distribution | Based on Table 1A in Report ITU-R M.[RLAN REQ-PAR] (The outdoor usage ratio is 5.3%) |
| Antenna pattern for RLANs | Based on Recommendation ITU-R M.1652 (If the RLAN uses e.i.r.p. of 1 W, the elevation angle mask defined for 5 250-5 350 MHz band in the Resolution **229 (Rev.WRC-12)** is applied.) |
| Height of RLAN antenna | 4.5 m |

| Parameters | Values and conditions |
|---|---|
| Active ratio of RLANs | 4.645% (derived from Report ITU-R M.[RLAN REQ-PAR]) |
| Building entry loss | Based on Recommendation ITU-R P.2109 (Building type: Traditional (The loss will be lower.), probability: $p$ = 0.5) |
| Clutter loss | Based on Recommendation ITU-R P.2108 (percentage of locations: $p$ = 0.5) under the assumption that this recommendation is applied to the 5.2 GHz band |

*[***Editor's note:*** Further clarifications are needed with regard to the probability used in Recommendation ITU-R P.2109, ITU-R P.2108 and active ratio of RLANs.]*

Under these conditions, the total amount of interference level is calculated with Monte Carlo simulations and compared with the allowable interference level with random locations of RLAN devices with variable number of RLANs within the coverage of the satellite feeder uplink antenna as shown in Figure A1. The results are the following as shown in Table A2. If the number of RLANs of the 5 150-5 250 MHz band within the coverage of the satellite feeder uplink antenna is less than 113.91 million (6.04 million for outdoor use), which corresponds to 63.85 million (3.38 million for outdoor use) RLANs in the footprint of the satellite, the average of the total amount of interference from RLANs is less than the threshold.

[Therefore, if the number of RLANs within the coverage of the satellite feeder uplink antenna is limited, the sharing with non-GSO MSS feeder links is possible when WAS/RLAN systems are used outdoors.]

FIGURE A1

**Interference from RLANs to the MSS feeder links**

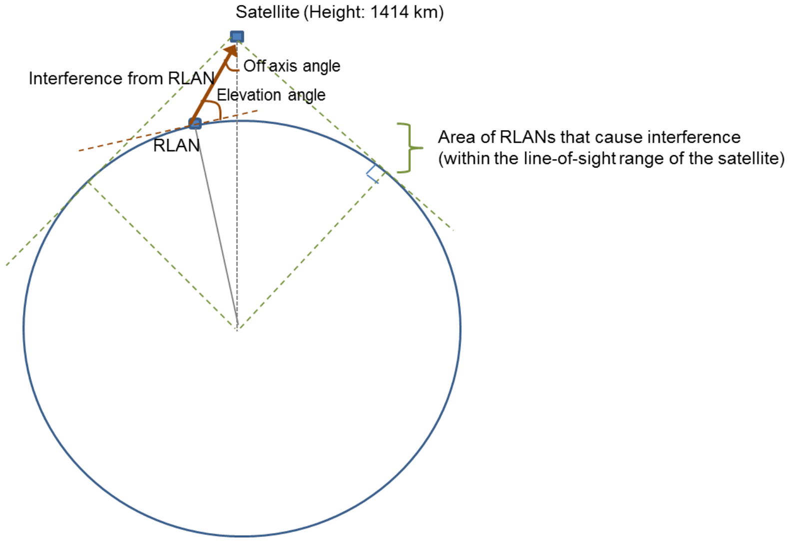



TABLE A2

**The upper limit of the number of RLANs using the 5 150-5 250 MHz band**

| | **The number of RLANs using 5 150-5 250 MHz (million).** |
|---|---|
| Within the coverage of the satellite feeder uplink antenna<br>(For outdoor use (5.3%)) | 113.91<br>(6.04) |
| In the footprint of the satellite<br>(For outdoor use (5.3%)) | 63.85<br>(3.38) |

### 5.1.6 Study 6 (FRA 5A/616)

In this study, we consider several cases of indoor/outdoor/ EIRP RLAN distribution.

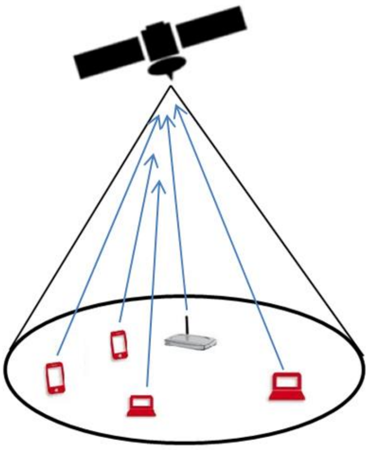
More than that, since the 5 150-5 250 MHz band is the only band where the DFS is not mandatory, and given the RTTT and radars deployment in the 5.8 GHz, this study would like to trigger the discussions on the possibility of enabling outdoor usage, with a limited power and restricted to in-vehicle usage.

#### 5.1.6.1 Methodology

The methodology used below consists in determining, in a dynamic analysis, the Cumulative Distribution Function (CDF) of interferences arising from the aggregated power of RLAN systems to the MSS receiver (Figure 10). Only the uplink path is studied in this paper.

FIGURE 8~~0~~

**Aggregate interference into the satellite**



The total aggregate interference is the sum of contributions of each RLAN in the visibility of the satellite and can thus be written as follows

$$I(dB) = 10\log\left(\sum_{n=1}^{n=N} 10^{[Pt_n + Gt_n + Gr_n - Loss_n - BF_n]/10}\right) \quad (1)$$

where:

- $N$ is the total number of RLANs in the visibility of the satellite;
- $Pt_n$ is the $n^{th}$ RLAN EIRP (dBm);
- $Gt_n$ is the $n^{th}$ RLAN Gain toward the satellite (dBi);
- $Gr_n$ is the Relative antenna gain (dBi) of the MSS receiver in the direction of the RLAN of index $n$;
- $Loss_n$ is the calculated losses between the RLAN of index $n$ and the MSS receiver, this value takes into account: the free space loss, the Building Entry Loss, the Clutter Loss and the polarization mismatch;
- $BF_n$ is the Bandwidth factor correction associated to the $n^{th}$ RLAN, due to the fact that the MSS receiver and the RLAN do not have the same bandwidth, $BF_n(dB) = 10 * Log_{10}\left(\frac{BW_{RLAN}}{BW_{MSS}}\right)$.

This interference value is computed for each satellite position and then is used to deduce the *I/N (dB)* or the $\frac{\Delta T}{T}(\%)$. Repeating this operation for several satellite positions allows us to build a Cumulative Distribution Function (CDF) associated to the vector of observation.

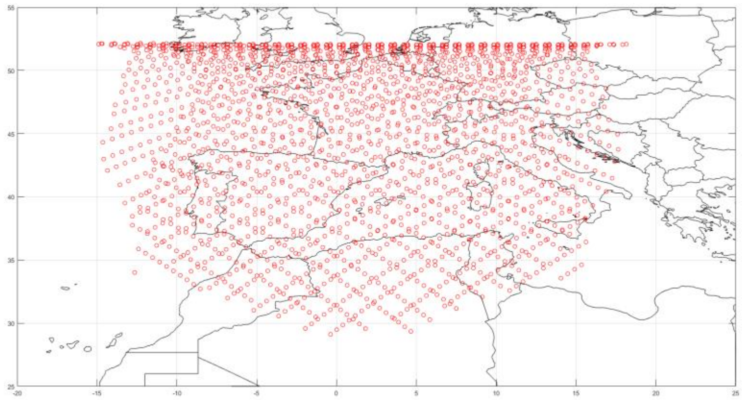
### 5.1.6.2 Scenario

The simulation determined the level of interference that would be experienced by a feeder link carrier that was uplinked from the earth station in Aussaguel, France (Latitude=43.42°, Longitude = 1.49°). This uplink carrier was switched from one spacecraft to another based on whichever spacecraft was the closest to the earth stations.

The simulation time step in our scenario was 10 Seconds, meaning that the satellite positions were recorded each 10 seconds. A quarter day of observation was taken into account (6h of record each 10 seconds), leading to 2 160 snapshots (All depicted in Figure11).

FIGURE 9

**Set of the satellites positions taken into account during the simulations**



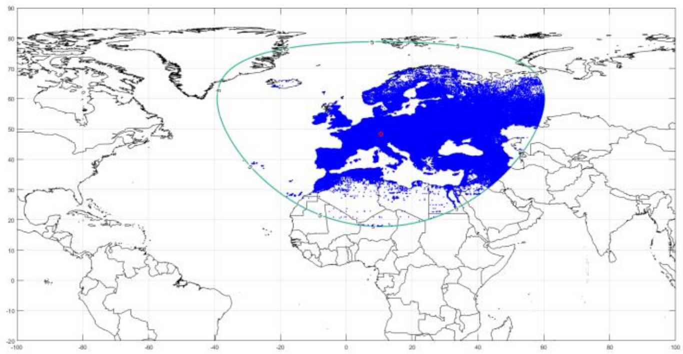
At each step, the aggregate RLAN interference into the satellite is computed using equation (1) and recorded into a storage vector. One should note that all the RLAN within the 5degree elevation contour (on ground) from the RLANs to the satellite are taken into account (Mainly from Europe, north of Africa and west of Asia.

An example is depicted in Figure12, the satellite position (red circle) is Lat=46.8570°, Long=1.1860°. The five degree elevation contour is plotted in the same figure in green, and all the RLAN seeing the satllite with an elevation higher than 5 degrees are plotted in blue (over Europe, Africa and Asia). For information, this correspounds to 1 679 414 simultaneous active RLANs.

Simulations are also carried out, when taking into account the mitigation technique applied in US to minimize RLAN harmful interference to the spacecraft. As presented in Doc. 5A/210, RLAN with antenna elevation angles in excess of 30 degrees from the horizon must not exceed 125 mW EIRP.

FIGURE 10~~2~~

**Example of RLANs taken into account in the interference computation for a satellite at position (Lat=48.326°, Long=10.489°). Green line is the 5° elevation contour, blue points are the RLANs and Red circle is the Satellite position.**



### 5.1.6.3 RLAN parameters taken into account in the simulations

#### 5.1.6.3.1 RLAN EIRP

The RLAN EIRP taken into account in the simulation are the ones according to Table 1A and Table 3A, from the WDPNR ITU-R M.[RLAN REQ-PAR], Annex 27 to WP 5A Chairman's Report.

TABLE 2

**RLAN EIRP according to Table 1A**

| RLAN e.i.r.p Level | 1 W (directional)* | 1 W (omni) | 200 mW (omni) | 80 mW (omni) | 50 mW (omni) | 25 mW (omni) | All |
|---|---|---|---|---|---|---|---|
| Indoor | 0% | 0% | 18% | 25.6% | 14.2% | 36.9% | 94.7% |
| Outdoor | 0.10% | 0.20% | 0.95% | 1.35% | 0.75% | 1.95% | 5.3% |

* In the absence of antenna pattern the directional nature is taken into account only through the antenna discrimination toward the satellite, which is also applied to other omnidirectional devices

TABLE 3

**RLAN EIRP according to Table 3A**

| RLAN e.i.r.p. Level | 1 W (directional)* | 200 mW (omni) | 80 mW (omni) | 50 mW (omni) | 25 mW (omni) | All |
|---|---|---|---|---|---|---|
| Indoor | 0% | 16.15% | 22.95% | 12.75% | 33.15% | 85% |
| Outdoor | 2.85% | 0% | 4.05% | 2.25% | 5.85% | 15% |

*In the absence of antenna pattern the directional nature is taken into account only through the antenna discrimination toward the satellite, which is also applied to other omnidirectional devices

Another distribution is proposed in Table 3, this latter takes into account the U.S. license-exempt rules for RLANs operating in the 5 150-5 250 MHz band, as presented in Doc. 5A/210 during the November 2016 WG 5A meeting.

TABLE 4

**Proposed distribution when taking into account the US rules in the band 5 150-5 250 MHz**

| **RLAN e.i.r.p. Level** | **4W (directionnal)*** | **1 W (directional)*** | **200 mW (omni)** | **80 mW (omni)** | **50 mW (omni)** | **25 mW (omni)** | **All** |
|---|---|---|---|---|---|---|---|
| Indoor | 0,00% | 0,00% | 15,15% | 21,95% | 11,75% | 31,15% | 80% |
| Outdoor | 3,00% | 2,85% | 2,00% | 4,05% | 2,25% | 5,85% | 20% |

*In the absence of antenna pattern the directional nature is taken into account only through the antenna discrimination toward the satellite, which is also applied to other omnidirectional devices

*[**Editor's note:** The figures depicted in the table could be updated according to the results of preliminary new Report ITU-R M.[REQ-PAR].]*

Finally, France also proposes to take into account the possibility to allow RLAN outdoor usage exclusively in vehicles in the 5 150-5 250 MHz. The flowing distribution is proposed for this case. An additional attenuation of *5 dB* should be taken into account to reflect the loss due to the vehicle's body.

TABLE 5

**Other proposed simulation scenario for vehicular usage**

| **RLAN e.i.r.p Level** | **200 mW (omni)** | **80 mW (omni)** | **50 mW (omni)** | **25 mW (omni)** | **All** |
|---|---|---|---|---|---|
| Indoor | 16.15% | 22.95% | 12.75% | 33.15% | 85% |
| Outdoor on a vehicle* | 1.5% | 6% | 4.5% | 3% | 15% |

* An additional attenuation of 5 dB should be taken into account for the outdoor RLANs in order to reflect the loss due to the vehicle screening.

*[**Editor's note:** The figures depicted in the table could be updated according to the results of the preliminary draft new Report M.[REQ-PAR].]*

### 5.1.6.3.2 RLAN Bandwidth

The RLAN EIRP taken into account in the simulation are the ones according to Table 1A and Table 5A, from the WDPNR ITU-R M.[RLAN REQ-PAR], Annex 27 to WP 5A Chairman's Report.

TABLE 6

**RLAN Bandwidth**

| **RLAN Transmitter Bandwidth** | **20 MHz** | **40 MHz** | **80 MHz** | **160 MHz** |
|---|---|---|---|---|
| RLAN Device Percentage | 10% | 25% | 50% | 15% |

#### 5.1.6.3.3 RLAN Antenna Gain discrimination towards the satellite

The considered RLAN antenna gain discrimination towards the satellite is as supported by the French contribution dealing with the aggregate RLAN measurement submitted to November 2017 GT 5A meeting, namely $Gt_n$ =-4dB.

#### 5.1.6.3.4 RLAN Density and distribution

France considers that the density of simultaneous Active RLAN (AR) per inhabitant should be **0.0022** RLAN/inhabitant as supported by the French contribution dealing with the aggregate RLAN measurement, submitted to November 2017 GT 5A meeting. This value is based on the statistics and prediction of the Joint Research Center (JRC) of 400 000 000 RLANs available in the market within 2025 (can be consulted at Ref.1 and Ref.2). This value is achieved using the following figures:

TABLE 7

**Methodology to deduce the RLAN density per inhabitant in Europe**

| Scenario | Number of AP | Busy hour factor | 5 GHz Spectrum factor | RF activity factor | BW factor | Total number of on-tune RLAN in Europe | Number of Inhabitant | RLAN Density / Inhabitant |
|---|---|---|---|---|---|---|---|---|
| Europe | 400 000 000 | 62.7% | 59% | 10% | 11% | 1 602 962 | 728 619 134 | 0,00222582 |

In the absence of any data regarding Africa and Asia, the density of RLAN per inhabitant is divided by 4 for these two continents (namely 5.5000e-04 simultaneous Active RLAN/inhabitant).

Regarding the population density (required to achieve the RLAN distribution), we used the density of population filings provided by the CIESIN (Ref.3), which consists of estimates of human population by 2.5 arc-minute grid cell, the example of Europe is depicted in Figure . The population density grids are derived by dividing the population count grids by the land area grid and represent persons per square kilometer (which makes it very precise).

FIGURE 11

**Population density each 2.5 arc-minute over europe (log10 scale on the right)**

For each kilometer square, the number of simultaneous active RLANs is deduced and then this RLANs are randomly distributed within this km square, attributing thus a latitude and a longitude to each individual RLAN.

This approach is very interesting, since it allows deducing the elevation by which each RLAN is seeing the satellite (and *vice versa*) and the distance between the RLAN and the satellite. These two parameters are necessary to compute the Losses (free space, clutter and BEL) and the antennas gains (Satellite or RLAN).

### 5.1.6.3.5 RLAN heights

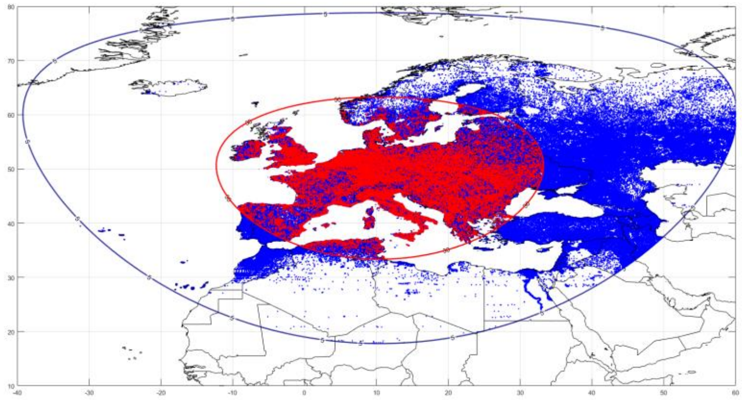
Two heights are considered for the RLAN: the first is 1.2m for terminals (70%) and the second one is 2 m for access points (30%).

### 5.1.6.3.6 Mitigation technique

In our simulation we also applied the technical rules for RLANs operating in the 5 150-5 250 MHz band in U.S, for comparison purposes. As presented in Doc. 5A/210, RLAN with antenna elevation angles in excess of 30 degrees from the horizon must not exceed 125 mW EIRP to minimize the likelihood of harmful interference to the operating MSS system. In our simulation, this is applied on the RLANs inside the 30° elevation contour. Statistically, this would have the same effect of attributing random elevations to all the RLANs and then applying it only to the ones with elevation greater than 30°. An example is depicted in Figure 14. In this case 4.2 % of the all observed RLANs are subject to the mitigation technique (70 581 over the 1 679 414 taken into account).

FIGURE 12

**Representation of the outdoor RLANs with antenna elevation greater than 30 degrees and with EIRP subject to the mitigation technique, in red points.**



### 5.1.6.4 Satellite parameters

#### 5.1.6.4.1 FSS Feeder link parameters

The case of the MSS system identified among ITU-R registrations as HIBLEO-X is studied. This system utilizes 48 spacecraft at an altitude of 1 414 kilometers and an inclination angle of the orbits of 52 degrees, with respect to the equator (see Figure 15).

The parameters of the feeder uplinks are summarized in Table 5, as provided in the GlobalStar contribution during the WG 5A May 2017 meeting (Doc. 5A/395).

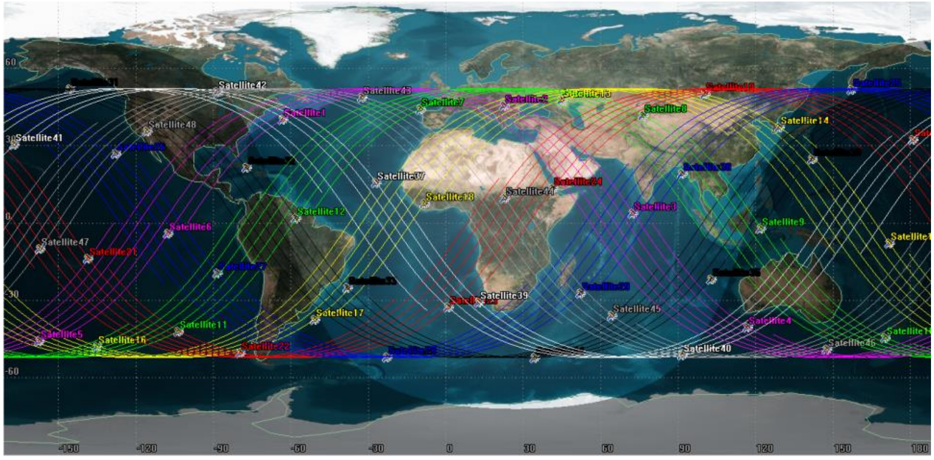
TABLE 8

**MSS feeder Link Parameters**

| Parameter | HIBLEO-4 FL |
|---|---|
| Satellite receiver noise temperature T (K) | 550 |
| Satellite receiver bandwidth B (MHz) | 16.5 |
| Protection criterion (dB) | -12.2* |
| * | |

FIGURE 13

**GlobalStar Constellation (HIBLEO-X)**

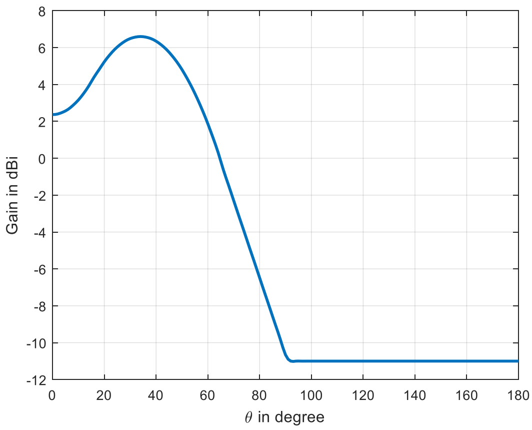


#### 5.1.6.4.2 Spacecraft receive antenna pattern

The spacecraft antenna pattern is the one depicted in Globalstar's contribution to WP 5A May 2017 in (Doc. 5A/395).

FIGURE 14

**Spacecraft Receive Antenna Pattern versus off-nadir angle**




#### 5.1.6.5 Propagation Loss

Four losses are taken into account in the path from the RLAN to the spacecraft:

- *Free-space loss*, according to Rec. ITU-R P.525;

- *Building Entry Loss (BEL),* according to the new recommendation being developed within WP-3K, Draft new Recommendation ITU-R P.2109. In the simulations, a mixture of 30% thermally efficient houses and 70% of traditional houses is considered. Regarding the probability that loss is not exceeded, for each RLAN the probability that loss is not exceeded is picked up in the interval [0,1] according to a uniform law (bear in mind that there is up to 1.6 million RLAN within the satellite coverage);
- *Clutter Loss,* according to Recommendation ITU-R P.2108-0 as advised by WP 3K. To do so, the clutter type is required. According to RLAN deployment density statistics in Europe (see Ref.1and Ref.2), 50% of households in the EU-28 area are located in densely populated areas, 23% in intermediate urban areas and 27% in thinly populated areas. These three areas are mapped to the urban, suburban and sparse homes clutter environments (see example over Europe in Figure 17). In the absence of any data for Africa and Asia, the same repartition is applied for these two continents as well. For information all the statistics are mapped in Table 10. Regarding the percentage of locations, the same procedure as for the BEL is used, for each RLAN a percentage of time is picked up in the interval [0,1] according to a uniform law;
- *Polarization mismatch,* a value of 3 dB is considered according to what have been supported by France in during TG-5.1 (see Doc TG-5.1/104).
- *Vehicle screening attenuation*, in this contribution being conservative, we considered an attenuation of **5 dB** due to vehicle screening. *It is applied only for the scenario described in Table 4*. According to CEPT report 17, in the frequency range 3-6 GHz, cars with metallized windows provide a mean attenuation of about 15 dB and cars without any metallized windows provide a mean attenuation of about 8 dB. Cars with one window being metallized (front window) provide a mean attenuation of 12 dB.

FIGURE 15

**Clutter type over Europe and parts of north Africa and Asia, Red (Urban), Yellow (Suburban) and Blue (Rural)**

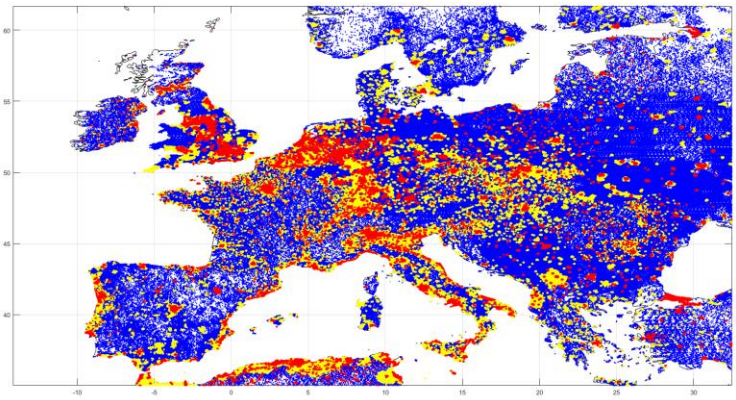


TABLE 9

**Statistics for the three continents according to the data provided in Ref.3 and to the urban, suburban and rural apportionment used in our simulations**

| Continent | Number of Inhabitant | Simultaneous active RLAN density per Inhabitant | Total number of active RLAN density per Inhabitant | Urban | Suburban | Rural |
|---|---|---|---|---|---|---|
| Europe | 728 619 134 | 0,0022 | 1 602 962 | 802 239 | 431 159 | 369 564 |
| Africa | 812 404 910 | 0,00055 | 446 822 | 225 199 | 103 455 | 118 168 |
| Asia | 3 676 824 724 | 0,00055 | 2 022 253 | 1 012 769 | 465 666 | 543 818 |

### 5.1.6.6 Simulation results

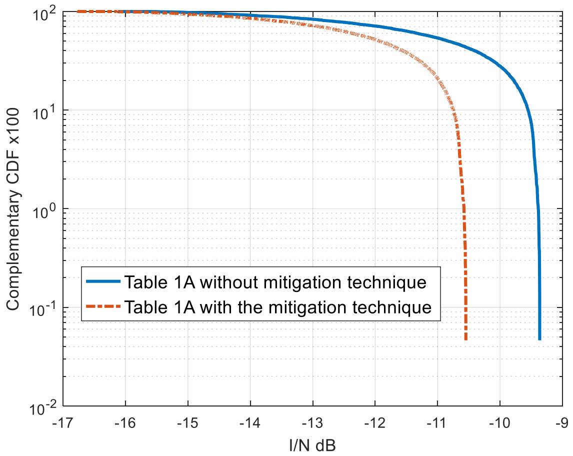
In the following the three scenarios presented in Tables 1, 2, 3 and 4 are studied. The complementary cumulative distribution function is plotted based the computed I/N for all the positions of the satellite depicted above.

#### 5.1.6.6.1 Results for Table 1

Figure 18 depicts the simulation results assessed according to Table 1 (Table 1A in preliminary draft new Report ITU-R ~~Doc.~~ [RLAN REQ-PAR]). We can observe, that the protection criterion of I/N=-12.2 dB (namely 6% for ΔT/T), is exceeded 73.5% of time when the mitigation technique is not applied and 56.5% of the time when the mitigation technique is applied. One shall notes that the case described in Table 1, take into account 5% of outdoor usage, which is mainly the accidental outdoor usage. The exceedance in I/N is about 3 dB.

FIGURE 16

**Simulation results with and without the mitigation technique according to Table 1**

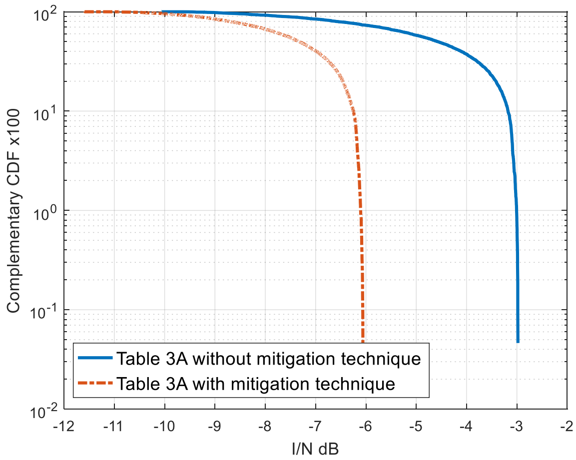



### 5.1.6.6.2 Results for Table 2

Figure19 depicts the simulation results assessed according to Table 3A (~~Doc.~~ preliminary draft new Report ITU-R [RLAN REQ-PAR]). We can observe, that the protection criterion of I/N=-12.2 dB is exceeded for all the satellites positions studied in our simulations scenario. The mitigation technique allows to reduce the exceedance of the criterion protection by ~3 dB.

FIGURE 17

**Simulation results with and without the mitigation technique according to Table 2**

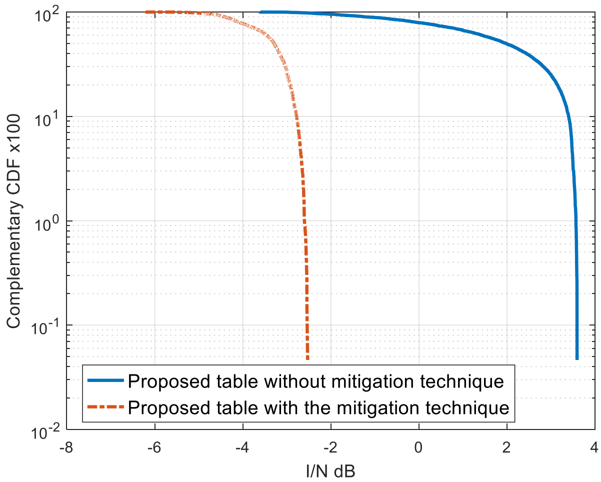



### 5.1.6.6.3 Results for Table 3

Figure 20 depicts the simulation results according to Table 3 of this document. Here again, we can observe, that the protection criterion of I/N=-12.2 dB, is exceeded for all the satellites positions studied in our simulations scenario. The mitigation technique allows to reduce the exceedance of the criterion protection by ~6 dB.

FIGURE 18

**Simulation results with and without the mitigation technique according to Table 3**

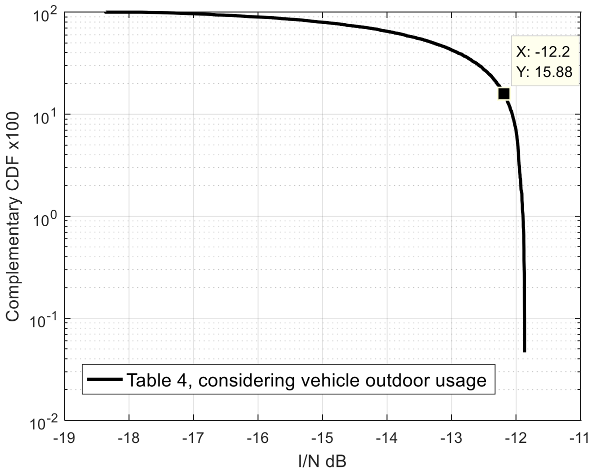



### 5.1.6.6.4 Results for Table 4

Finally, Figure 12 depicts the results for Table 4. This table proposes an outdoor usage restricted to vehicular application. As stated earlier a 5 dB attenuation is added to take into account the body loss of the vehicle. In this particular case we observe that the protection criterion is exceeded by less ~~that~~than 1 dB only 15,88% of the time. According to those results the solution of vehicular outdoor deployment in this band seems to be the best solution to ensure the protection of the MMS feeder uplink.

FIGURE 19

**Results for Table 4, outdoor vehicle usage, 5 dB additional attenuation to reflect vehicle screening effect.**




### 5.1.6.7 Conclusions

In this paper we studied the possible impact of relaxing the outdoor usage of RLANs in the band 5 150-5 250 MHz, as well as the power rise. According to our simulation, we can drive the following conclusions:

- Results according to Table 1 show an exceedance of less than 3 dB of the protection criterion is encountered. This scenario corresponds more likely to accidental outdoor usage, and it is very unlikely to be able to control such a percentage of outdoor usage by the administrations.
- Results according to tables 2 and 3, take into account 15% to 20% of outdoor usage with a power rise to 1W or 4W, in these cases the protection criterion is never respected according to our simulations, and seem to be harmful for MSS. Even with the mitigation technique proposed in Doc 5A/210 the protection criterion could not be reached. More specifically it appears to be very difficult to monitor the antenna elevations deployment in a License exempted regime.
- Finally, we considered a case of outdoor relaxation limited to in-vehicle usage, taking into account a maximum EIRP of 200 mW and taking into account a 5 dB loss due to the vehicle body, this scenario seems to be the most suitable for outdoor RLAN usage in the 5 150-5 250 MHz band, specially that this band is DFS free.

### 5.1.6.8 References

[1] JRC study on RLAN deployment and device densities: http://www.cept.org/Documents/se-24/25709/SE24(15)070R0_WI52_number-of-RLAN-JRC

[2] JRC study on in-home RLAN coverage and number of RLAN APs per household: http://www.cept.org/Documents/se-24/25805/SE24(15)089R0_WI52_Further-considerations-on-WLAN-indoor-coverage

[3] Center for International Earth Science Information Network - CIESIN - Columbia University, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Density Grid. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H4XK8CG2, accessed August 2017.

### 5.2 Sharing and compatibility of Aeronautical radionavigation versus WAS/RLAN in the 5 150-5 250 MHz

#### 5.2.1 Study 1 (RUS 5A/397)

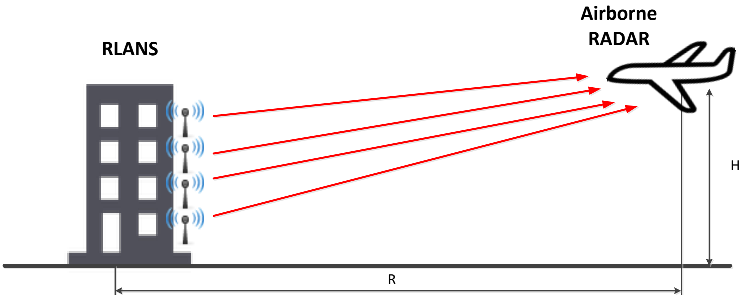
The analysis of Recommendation ITU-R M.2007 shows that it contains only description of airborne sense and avoid systems with the maximum permissible interference-to-noise ratio (I/N) as the protection criterion at the receiver input.

Therefore the potential interference scenario given in Figure 1 was used in the studies.

It is proposed to define the maximum permissible interference level at the airborne radar receiver input to estimate the WAS/RLAN system impact to the airborne radar receivers.

FIGURE 1

**Interference scenario for airborne radiodetermination radar receiver**




Based on the obtained value the minimum protection distance ensuring compatibility of WAS/RLAN systems with airborne radar receivers can be defined.

The maximum permissible interference power at the receiver input is estimated by the following equation:

$$I_{acc} = N + (I/N)_{req}, \text{ dBW,} \tag{1}$$

where: $(I/N)_{req}$ - required interference/noise ratio at the receiver input;

$$N = 10 * \lg(k T_N \Delta F_{RLS}) \text{ dBW,} \tag{2}$$

$k$ – Boltzmann constant,

$$T_N = 290 * \left(10^{\frac{NF}{10}} - 1\right) \text{ – noise temperature, degrees K,} \tag{3}$$

$NF$ – radar noise figure, dB;

$\Delta F_{RLS}$ - radar operating frequency band, Hz

To estimate compatibility of RLAN with airborne radars (Scenario 1) the required protection distances were determined to ensure operation of the radars without interference in different operation modes of RLANs. The protection distance was determined in accordance with propagation model provided in Recommendation ITU-R P.525 by the following equation:

$$R = 10^{\frac{EIRP_{eff} + G_{RLS} + 20\lg(\lambda/4\pi) - I_{acc}}{20}}, \qquad (4)$$

where

$$EIRP_{eff} = EIRP_{RLAN} + 10\lg\left(\Delta F_{RLS} / \Delta F_{RLAN}\right) - \sigma, \qquad (5)$$

$G_{RLS}$ - radar antenna gain, dB;

λ – operational wavelength, m;

σ – cross-wall fading, dB.

$$R = 10^{\frac{EIRP_{eff\,1} + 10 * \lg(N) + G_{RLS} + 20\lg(\lambda/4\pi) - I_{acc}}{20}}, \qquad (6)$$

where: $EIRP_{eff\ 1}$- effective e.i.r.p. of single WAS/RLAN transmitter;

$N$ – number of WAS/RLAN transmitters.

The estimations assumed an aircraft flying at 10 km altitude (H=10 000 m). Interference to operation of the air-borne receiver of sense and avoid system is caused by indoor and outdoor RLAN transmitters. The free space propagation model described in Recommendation ITU-R P.525 is used to estimate the interference caused by RLAN transmitters. To take propagation loss in the walls into account in equation (4) additional propagation loss, σ, equal to 20 dB was considered. Multi-source interference was taken into account using equation (6).

The permissible interference power at the airborne sense and avoid receiver input was calculated by the equation (2)-(4) indicated above and is equal to minus 131.9 dBW. It was used to determine the required protection distances providing interference free radar operation in case of indoor and outdoor WAS/RLAN systems operation.

Table 3 presents the calculation results of the protection distances required between the airborne receivers of sense and avoid radar and single outdoor and indoor RLAN transmitters.

TABLE 3

**Separation distances required for protection of air-borne radars from indoor and outdoor RLAN, KM**

| | **$EIRP_{eff}$=-7 dBW, σ=20 dB** | | **$EIRP_{eff}$=-7 dBW, σ=0 dB** | |
|---|---|---|---|---|
| $\Delta F_{RLAN}$, MHz | 20 | 160 | 20 | 160 |
| Protection distance | 51 | 18 | >$R_{LOS}$ | 180 |

*$R_{LOS}$ – line-of-sight distance equals 430 km for a typical flight altitude of 10 000 m and WAS/RLAN transmitter height of 20 m.

The analysis of the results provided in Table 3 shows that in case of outdoor WAS/RLAN systems usage the required protection distance can be increased significantly in comparison with the case of indoor WAS/RLAN deployment. Such usage even of single outdoor WAS/RLAN usage can lead to the case when the required protection distance will exceed the line-of-sight distance for a certain bandwidth of WAS/RLAN system.

In addition the required protection distances were estimated in case when three RLAN transmitters deployed in one building operate simultaneously. The estimation results are presented in Table 4.

TABLE 4

**Separation distances required for protection of airborne radars from three indoor and outdoor rlan systems, km**

| | **$EIRP_{eff}$=-7 dBW, σ=20 dB** | | **$EIRP_{eff}$=-7 dBW, σ=0 dB** | |
|---|---|---|---|---|
| $\Delta F_{RLAN}$, MHz | 20 | 160 | 20 | 160 |
| Protection distance | 88 | 31 | >$R_{LOS}$ | 311 |

While increasing the number of outdoor WAS/RLAN systems falling into the main lobe of the airborne sense and  avoid antenna pattern up to 7 the required protection distance exceeds the line-of-sight distance for both types of the considered WAS/RLAN signals.

The obtained results allow to conclude that the compatibility of outdoor WAS/RLAN systems with the airborne radars will be quite complicated without taking the additional measures for reducing interference.

### 5.2.2 Study 2 (JPN 5A/586)

*[**Editor's note:** The text below need to be carefully considered at next WP 5A meeting, especially for the probability.]*

Another example of a sharing study with realistic conditions is conducted as follows.

The parameters and protection criteria of the ARNS system are assumed to be almost the same as described in section 4.1 (also described in Recommendation ITU-R M.2007) and the threshold of the total amount of interference from RLANs is -101.9 dBm with the following conditions in Table A3.

TABLE A3

**Additional conditions for a sharing study with ARNS systems**

| **Parameters** | **Values and conditions** |
|---|---|
| e.i.r.p. distribution | Based on Table 1A in Report ITU-R M.[RLAN REQ-PAR] (The outdoor usage ratio is 5.3%) |
| Antenna pattern for RLANs | Based on Recommendation ITU-R M.1652 (If the RLAN uses e.i.r.p. of 1 W, the elevation angle mask defined for 5 250-5 350 MHz band in the Resolution **229 (Rev.WRC-12)** is applied.) |
| Height of RLAN antenna | 4.5 m |
| Active ratio of RLANs | 4.645% (derived from Report ITU-R M.[RLAN REQ-PAR]) |
| Antenna pattern for ARNS systems | Based on Recommendation ITU-R M.1652 (The maximum antenna gain is 36 dBi as defined in Recommendation ITU-R M.2007.) (*1) |
| Altitude of ARNS systems | 10 km |
| Building entry loss | Based on Recommendation ITU-R P.2109 (Building type: Traditional (The loss will be lower.), probability: p = 0.5) |
| Additional loss | 17 dB (defined for airborne radars in Recommendation ITU-R M.1652). |

(*1) Recommendation ITU-R M.2007 specifies the maximum antenna gain. However it does not contain antenna patterns. This sharing study adopts antenna patterns used in Annex 6 to Recommendation ITU-R M.1652.

Under these conditions, the total amount and distribution of interference level is calculated based on Monte Carlo simulations and compared with the allowable interference level with random locations of RLAN devices with variable number of RLANs within the line-of-sight range of the ARNS systems as shown in Figure A2.

The minimum distance between RLANs and ARNS systems is assumed to be 0 km or 20 km. The elevation angle of the ARNS antenna is assumed to be -45 degrees that is the lower limit and corresponds to the maximum interference level from a RLAN device near the ARNS system.

The results are shown in Table A4. When no limitation is applied to RLAN locations, if the upper limit of the number of RLANs of the 5 150-5 250 MHz band within the line-of-sight range of the ARNS system is 103.15 million (5.47 million for outdoors), the interference is less than the threshold with a probability of 90%. When the minimum distance between RLANs and ARNS systems is 20 km, the upper limit of the number of RLANs is 210.79 million (11.17 million for outdoor use) in the same way.

Accordingly if the number of RLANs or the separation distance between RLANs and ARNS systems is controlled, the interference level will be less than the threshold with a certain probability. Therefore the sharing with ARNS systems is possible when WAS/RLAN systems are used outdoors.

FIGURE A2

**Interference scenario from RLANs to ARNS systems**

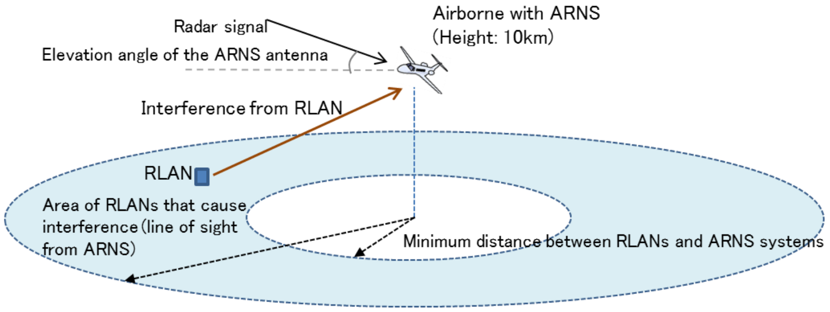



TABLE A4

**The upper limit of the number of RLANs that cause interference levels less than the threshold with a probability of 90%**

| | **Minimum distance between RLANs and ARNS systems: 0 km** | **Minimum distance between RLANs and ARNS systems: 20 km** |
|---|---|---|
| The number of RLANs using 5 150-5 250 MHz within the line-of-sight range of ARNS systems (million) (For outdoor use (5.3%)) | 103.15<br>(5.47) | 210.79<br>(11.17) |

## 5.3 Sharing and compatibility of Aeronautical Mobile Service limited to aeronautical mobile telemetry (AMT) for flight testing versus WAS/RLANs in the 5 150-5 250 MHz band

*[TBD]*

# 6 Conclusions of sharing and compatibility studies per service

## 6.1 General considerations

## 6.2 Sharing and compatibility results in the band 5 150-5 250 MHz

*[USA 5A/381]*

Some administrations have enabled RLAN operations that are beyond restrictions specified in Resolution **229 (Rev.WRC-12)**. Specifically, these administrations authorized RLAN use of this band in co-existence with MSS operations through e.i.r.p. limitations at higher antenna elevation angles: the authorization generally permits indoor and outdoor RLAN operations in 5 150-5 250 MHz at up to 1 Watt conducted and a power spectral density (PSD) of 17 dBm/MHz with an allowance for a 6 dBi antenna gain (*i.e.* a total 36 dBm e.i.r.p.). The outdoor operation of WAS/RLANs devices are permitted in the 5 150-5 250 MHz band at these power levels, except that such operations with antenna elevation angles in excess of 30 degrees from the horizon must not exceed 125 mW e.i.r.p. to minimize the likelihood of harmful interference to the operating MSS system. Expressing a limit in terms of e.i.r.p. provides flexibility regarding how to achieve compatibility with non-GSO MSS feeder uplinks. It is important to note that one of these administrations is also the notifying administration for the single non-GSO MSS system operating in this band and that, to date, no interference issue have been reported to that administration's regulator. Also, while in-band e.i.r.p. was increased, unwanted emission levels were retained such that all WAS/RLAN station emissions outside of the 5 150 – 5 350 MHz frequency range shall not exceed an e.i.r.p. of −27 dBm/MHz

*[RUS 5A/397]*

The results of the conducted studies allow to make the following conclusions:

– sharing of outdoor WAS/RLAN systems operating in the frequency band 5 150-5 250 MHz having the current characteristics with airborne sense and avoid systems is unfeasible;

– the effective measures for reducing interference for airborne sense and avoid systems operation are to be developed to enable the usage of outdoor WAS/RLAN in the frequency band 5 150-5 250 MHz. The reduction of e.i.r.p values of WAS/RLAN transmitters approximately by 20 dB while increasing the receiver sensitivity can be considered as the effective method for reducing interference. Such method allows to compensate the absence of additional fading in the walls which provided sharing of WAS/RLAN systems with the ARNS systems operating in the considered frequency band.

Without development and implementation of such measures for reducing the interference the decision of possible outdoor WAS/RLAN systems usage in the considered frequency band cannot be made.

*[JPN]*

Regarding outdoor operations of WAS/RLAN systems in the 5 150-5 250 MHz band, the results of some examples of sharing studies show that WAS/RLAN systems are compatible with non-GSO MSS feeder links and ARNS systems. As an interference mitigation technique, the elevation angle mask defined for the 5 250-5 350 MHz band in Resolution **229 (Rev.WRC-12)** is effective. In addition, limitation of the number of RLAN devices, ensuring the minimum distance between RLANs and ARNS systems and the limitation of the locations of RLANs are also effective.

LIST OF REFERENCES

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[2] ECC Decision (04)08: "Harmonised use of 5 GHz for the implementation of WAS/RLANs"

[3] WRC Resolution 229 (WRC-03): "Use of the bands 5 150-5 250, 5 250-5 350 MHz and 5 470-5 725 MHz by the mobile service for the implementation of Wireless Access Systems including Radio Local Area Networks"

[4] ERC Report 67: "Study of the Frequency sharing between HIPERLANs and MSS feeder links in the 5 GHz band"

[5] ERC Report 72: "Compatibility studies related to the possible extension band for HIPERLAN at 5 GHz"

[6] ETSI EN 301 893: "Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering the essential requirements of Article 3.2 of the R&TTE Directive"

[7] EC Decision 2005/513/EC complemented by EC Decision 2007/90/EC

[8] Recommendation ITU-R M.1739: "Protection criteria for wireless access systems, including radio local area networks, operating in the mobile service in accordance with Resolution 229 (WRC-03) in the bands 5 150-5 250 MHz, 5 250-5 350 MHz and 5 470-5 725 MHz"

[9] ERC Report 25: "The European table of frequency allocations and applications in the frequency range 8.3 kHz to 3000 GHz"

[10] EC Decision 2008/671/EC: "Commission Decision of 5 August 2008 on the harmonised use of radio spectrum in the 5 875-5 905 MHz frequency band for safety related applications of Intelligent Transport Systems (ITS)"

[11] ECC Decision (08)01: " ECC Decision of 14 March 2008 on the harmonised use of the 5 875-5 925 MHz frequency band for Intelligent Transport Systems (ITS)"

[12] ECC Recommendation (08)01: " Use of the band 5 855-5 875 MHz for Intelligent Transport Systems"

[13] ECC Report 101: "Compatibility studies in the band 5 855-5 925 MHz between Intelligent Transport Systems (ITS) and other systems"

[14] ECC Decision (12)04: " ECC Decision of 2 November 2012 on the withdrawal of ECC Decision (02)01. For national implementation issues related to the withdrawn Decision, check EFIS"

[15] ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)"

[16] ETSI EN 300 674: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band; Part 1: General characteristics and test methods for Road Side Units (RSU) and On-Board Units (OBU)"

[17] CENELEC EN 12253: "" Road transport and traffic telematics - Dedicated short-range communication - Physical layer using microwave at 5.8 GHz"

[18] ECC Report 68: "Compatibility studies in the band 5 725-5 875 MHz between Fixed Wireless Access (FWA) systems and other systems"

[19] ITU-R Recommendation P.452: "Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz"

[20] EC Decision 2006/771/EC: "Commission Decision of 9 November 2006 on the harmonisation of the radio spectrum for use by short-range devices"

[21] IARU Region-1 VHF Managers Handbook

[22] Recommendation ITU-R M.1732-1: "Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies"

[23] ECC Report 210: "Compatibility/sharing studies related to Broadband Direct-Air-to-Ground Communications (DA2GC) in the frequency bands 5 855-5 875 MHz, 2 400-2 483.5 MHz and 3 400-3 600 MHz"

[24] ETSI TR 101 599: "Electromagnetic compatibility and Radio spectrum matters (ERM) System Reference Document (SRDoc); Broadband Direct-Air-to-Ground Communications System employing beamforming antennas, operating in the 2,4 GHz and 5,8 GHz bands"

[25] ETSI TR 103 108: "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference document (SRdoc); Broadband Direct-Air-to-Ground Communications System operating in the 5,855 GHz to 5,875 GHz band using 3G technology"

[26] ECC Report 206: "Compatibility studies in the band 5 725-5 875 MHz between SRD equipment for wireless industrial applications and other systems"

[27] IEEE 802.11-2012: "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications"

[28] ETSI EN 302 571 V1.2.2 (2011-10): "Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive"

[29] Recommendation ITU-R SM.329: "Unwanted emissions in the spurious domain"

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[32] ETSI ES 200 674-1 V2.4.1 (2013-05): “Technical characteristics and test methods for High Data Rate (HDR) data transmission equipment operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band”

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[34] ETSI TR 102 960: "Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (RTTT

DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range; Evaluation of mitigation methods and techniques"

[35] ETSI TS 102 792: "Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range"

[36] http://www.statistiques-mondiales.com/union_europeenne.htm

[37] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lfst_hhnhtych&lang=en

[38] https://www.ssb.no/en/befolkning/statistikker/familie/aar/2014-12-12

[39] http://www.bfs.admin.ch/

[40] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bd_9ac_l_form_r2&lang=en

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[43] ECC Report 181 on improving spectrum efficiency in SRD bands

[44] JRC study on RLAN deployment and device densities: http://www.cept.org/Documents/se-24/25709/SE24(15)070R0_WI52_number-of-RLAN-JRC

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[46] JRC measurements of 802.11ac RLAN APs operating in the 5 GHz band: http://www.cept.org/Documents/se-24/24051/SE24(15)042R0_WI52_JRC_5GHZ_RLAN-_measurements

[47] ECC Report 244 "Compatibility studies related to RLANs in the 5 725-5 925 MHz band"

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# APPENDIX B

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**Document 5A/722-E**
**8 May 2018**
**English only**

## United States of America

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT ITU-R M.[RLAN REQ-PAR]

# Technical characteristics and operational requirements of WAS/RLAN in the 5 GHz frequency range

### Background

During the nineteenth meeting of Working Party 5A (WP 5A) in November 2017, there were discussions on including an e.i.r.p. distribution for sharing studies considering possible 4W operation in the 5 150-5 250 MHz band. A preliminary outdoor distribution was proposed during the meeting.

### Discussion

An extensive analysis of outdoor and indoor usage was conducted to provide a more accurate assessment of an e.i.r.p. distribution for the outdoor usage in the 5 150-5 250 MHz band only for use in sharing studies under WRC-19 agenda item 1.16. A detailed description is available in Appendix 1.

### Proposal

A proposed update to working document towards a preliminary draft new Report ITU-R M.[RLAN REQ-PAR] is provided in the embedded attachment.

RLAN_Req_Par.docx

**Appendix:** 1

# APPENDIX 1 – DISCUSSION

## e.i.r.p. Distribution Analysis

In order to accurately develop an e.i.r.p. distribution for the 5 150-5 250 MHz band, a detailed analysis was performed, taking into account available deployment numbers, growth assumptions and practical considerations. The results of this analysis proposes values for Table 1b of Document 5A/650 (Annex 21), *Report ITU-R M.[RLAN REQ-PAR]*. Table 1b is provided as Table 3 in the Document 5A/650 (Annex 23), *Report ITU-R M.[RLAN SHARING 5 150-5 250 MHZ]*.

### Indoor and outdoor allocations

In the Annex 2 of the last Joint Task Group of Working Parties 4, 5, 6, and 7 it was noted: "For the purposes of sharing studies, 5% of the devices should be modelled without building attenuation. Alternatively administrations may choose to carry out a parametric analysis in any range between 2% and 10%."

In producing an e.i.r.p. distribution table for 5 150 to 5 250 MHz studies, consideration was given to an alternate indoor and outdoor distribution of RLAN transmissions. Multiple sources provide evidence that a value less than the present 5.3% outdoor allocation used in studies of other bands may be more appropriate for this band.

The percent of indoor and outdoor RLANs was estimated, based on a review of various market data sources:

– Data gathered from U.S. cable Internet providers show that as of end of year 2017, 1.13% of all installations are outdoors.

– iPass data shows that 2.15% of all APs installed in the study area, as of end of year 2017 fell into the Public Access user group, the only group with outdoor APs. It is assumed that less than half of these would be installed outdoors.

– Data from the Small Cell Forum and a consulting group was added together on a yearly basis from 2014 through 2021, assuming only 50% of the small cells forecast would be involved in RLAN like transmissions in the 5 150 to 5 250 MHz band e.g. unlicensed or Licensed Assisted Access. The resulting outdoor percent of the total is 0.46% in 2017, 0.86% in 2021 and 0.58% cumulative over the whole period.

Data from the above sources indicate that 1% outdoor allocation is more realistic. However, to account for any unintentional emissions, the study assumes 2% APs are outdoor and 98% indoor. In order to achieve these distribution, all indoor and outdoor distribution percentages, other than the 4 and 1 watt values, as determined below, were adjusted as required.

### e.i.r.p. distributions

To define the e.i.r.p. distributions detailed, bottoms-up use case analyses were performed for outdoor and indoor environments separately.

*Outdoor RLAN e.i.r.p. level distribution derivation*

For the outdoor environment, the analysis needs to consider three questions:

1 How many devices could possibly exist that are 1 watt or 4 watt capable and compliant with the U.S. antenna mask and out-of-band power spectral density (PSD) requirements?

2 How many of these would possibly be used to transmit at high power, 1 or 4 watts?

3 For an active high power channel, what percent of the time would high power transmissions take place?

To answer the first question, we consider that, beginning one year after the effective date of the new rules (or June 2015, since new U.S. rules became effective June 2, 2014), all new applications for equipment certification of 4 watt outdoor devices were required to comply with the 30 degree antenna mask and out of band PSD e.i.r.p. requirement of −27 dBm/MHz. Two years after the effective date (June 2017), all 5 GHz devices manufactured or sold in the U.S. were required to meet the mask and PSD requirements while operating with an e.i.r.p. of 4 watts. In other words, many of the devices sold in the first two years were required to lower their transmit power to meet the mask and out of band PSD e.i.r.p. requirement of −27 dBm/MHz. While the required power reduction varied by device, the result is approximately 50% of the devices operating with an e.i.r.p. of 1 watt or less. We can estimate the number of 1 watt and 4 watt compliant devices that have been deployed from the previous iPass reference as well as information provided by an engineering study[1] with the assumption that 50% of outdoor devices between 2014 and 2015 operated at 1 watt, and 50% operated at 4 watts, while those from 2016 and 2017 are all 4 watt-capable/compliant, and all can operate in the 5 150-5 250 MHz band.

From our previous simulations the worst interference case resulted when a portion of Latin America and North America was covered by the NGSO feeder antenna resulting in an estimated 648 205 801 people driving RLAN deployments and potentially contributing to the satellite interference. This is about 13% of 2/3 of the 2017 global population[2], i.e., the fraction of the population driving RLAN deployments. We then increase this by 19% to 15.5%[3] to account for higher than average RLAN deployment in the study area. Figure 3-2 in the engineering study provides actual and projected indoor and outdoor Wi-Fi AP global shipments from 2012 to 2021. Aggregating outdoor AP shipments from 2014 through 2015 and 2016 through 2017, results in cumulative values of 620 500 and 1 086 100 worldwide outdoor devices shipped for each respective period. Multiplying this number by 15.5% gives a total of 95 991 and 168 020 for each respective period. Assuming 50% of the first number are 1 watt and 50% of the first number and 100% of the second number are 4 watt capable and compliant and dividing by the total APs deployed in the study area, as provided by iPass, we get 0.057% and 0.255% corresponding to the maximum estimate of 1 watt and 4 watt devices respectively that are capable of operating in the 5 150 to 5 250 MHz band and that would be available to be deployed.

To answer the second question we consider possible outdoor use cases. We identify three use cases of outdoor APs, high density/low power (e.g. stadiums or outdoor events), medium density/medium power (municipal and private networks, and high power omni AP (market-driven hotspots). It can be shown that to prevent self-interference and provide the capacity needed, APs associated with medium density deployments will operate with e.i.r.p.s typically 200 mW or less and high density deployments with even less. We note that outdoor medium and high density buildouts would normally account for a much larger part of the market at the outset since there is a known market demand and many APs are installed under a single focused project. In addition it takes more time to identify, prepare, and deploy individual hotspots installations. However, over time, high power hotspots and medium density networks will continue to be deployed while high density

[1] RKF Engineering Solutions, LLC, “Frequency sharing for radio local area networks in the 6 GHz band”, January 2018, https://ecfsapi.fcc.gov/file/101261169015803/6%20GHz%20Ex%20Parte%20(Bureaus).pdf.

[2] http://www.worldometers.info/world-population/.

[3] This number is interestingly supports the deployments provided by iPass and is almost identical to that shown for study area as a percent of worldwide broadband connectivity (see slide 19), https://seekingalpha.com/article/4057537-arris-international-arrs-investor-presentation-slideshow.

deployments will slow with saturation. Taking this into consideration a distribution of 20%/40%/40% is assumed for outdoor high density/medium density/hotspot AP deployments.

To answer the third question we conduct a simple hotspot use case analysis. We note that while channel activity is taken into consideration by application of the activity factor in Table 8, not every transmission during the RLAN's active period is operating at maximum power, i.e., 1 watt or 4 watt e.i.r.p. The transmission time is shared between the AP and its clients, which are not allowed to operate at 4 watts e.i.r.p. and unlikely to operate at 1 watt. The percent of time the AP will be transmitting on an active channel is dependent on the download and upload data requirements and the data rates that can be supported in each direction.

Although the network of a major technology and content provider[4] is a mesh network and is not reflective of high-power hotspots, it does provides data helpful in defining certain hotspot characteristics. The study defines two types of mobile users relevant to our analysis: those with smartphones and those with laptops. The distribution of active smart phone and laptop users during the busy hour is 740 and 1000 respectively. The network employs 500 APs with an average inter-site distance of 100 meters, so it covers approximately 5 km$^2$. The density of active users is 348 pops/km$^2$. Of the active users 42.5% are smartphone users and 57.5% are laptop users, from which a weighted mean transmission rate may be estimated from the CDF curves, as .0182 Mbps with a downstream to upstream transmission rate ratio of 4.18:1.

The client devices served on particular networks would have an impact on the hotspot design. For the high-traffic hotspots, in which the high-powered APs would be deployed, a distribution of smartphones, tablets and laptops would likely occur. The high-powered hotspots would generally be deployed by known entities such as wireless services providers and as such we assume the trusted location (outside the home), normalized distributions from the noted reference[5]. For average client device transmit power and antenna gain, a survey of U.S. device certifications[6] was conducted to determine typical maximum average conducted power and antenna gain. The certification-related reports can be obtained for each device FCC ID. These reports contain the transmitter conducted power and composite antenna gain. The conducted power reported is the maximum average conducted power measured in the 26 dB bandwidth resulting when the device is set to transmit at all combinations of power, bandwidth, modulation coding scheme, and antenna configuration options. The conducted power and antenna gain selected to represent each device is the combination that results in the least margin from the regulatory e.i.r.p. limit. The results are averaged across devices of similar type and provided in Table 1 of this Appendix, below.

4 http://cseweb.ucsd.edu/~snoeren/papers/google-ton.pdf.

5 https://www.statista.com/statistics/463301/wireless-internet-access-by-device-worldwide/.

6 https://www.fcc.gov/oet/ea/fccid#block-menu-block-4.

TABLE 1

**Outdoor hotspot device characteristics**

| Type | Phone | Tablet | Laptop | Client Device Avg | High Power Outdoor AP |
|---|---|---|---|---|---|
| Distribution | 44.4% | 23.5% | 32.1% | | 100% |
| Tx Pwr (dBm) | 19.9 | 19.1 | 19.0 | 19.5 | 24.9 |
| Ant gain (dBi) | -1.5 | 4.8 | 5.1 | 3.1 | 8.2 |
| EIRP (dBm) | 18.4 | 23.9 | 24.1 | 22.6 | 33.1 |

In a municipal network, the design objective is to ensure ubiquitous Internet access with a fairly high throughput. This necessitates moving APs closer together and lowering the power to prevent adjacent and co-channel interference. For the high-power hotspot the objective is to maximize access in a target area by way of high-power with minimize cost. While throughput is a secondary objective, additional APs with channel separation may be added to meet capacity demand in certain instances. It could be argued that the density of active users may be higher in the hotspot target area than would be found across the municipal network. However, because of the larger radius of coverage, there are likely to be more shadowed areas and some areas simply void of potential users so the active user density of 348 active pops/km$^2$ found in the major technology provider's network would be a reasonable value to use. Table 2 below provides the results of effectively the 4 watt hotspot design.

Losses of 1.1 dB and 3.5 dB were assumed due to implementation and obstruction (including body loss). In addition, Transmission Control Protocol (TCP) and multi-user Medium Access Control (MAC) overhead of 31% was assumed. No degradation due to interference was assumed. The mean throughput of .0182 Mbps objective was assumed and the cell size was adjusted to support this objective. From the downlink received signal level and a Modulation Coding Scheme (MCS-3), we see that there is excess capacity available. One of the consequences of such excess capacity is that the AP only needs to transmit 51% of time and clients 49% of the time, when the channel is active, even though the DN/UP demand is 4.2:1. In a similar manner, lowering the conducted power for the 1 watt e.i.r.p. case, the AP transmit time is 58.1%. It should be noted that the actual environment will include many older, less capable client devices, leading to an even lower percent transmission time from the hotspot APs.

TABLE 2

**Outdoor hotspot design**

| | | | |
|---|---|---|---|
| Density | 348.00 | Cell Radius | 876.00 |
| RSL Down | -73.98 | RSL UP | -79.42 |
| Trans Rates | DN/UP Ratio | Down | Up |
| Objective | 4.18 | 0.018 | 0.004 |
| Actual | 4.01 | 0.024 | 0.006 |
| Time Allocation | DN/UP | % DN | % UP |
| | 1.04 | 51% | 49% |

Considering the findings in answering the questions above, the study concludes that the percent of 4 watt e.i.r.p. AP transmissions can be calculated as 0.255% (4 watt capable APs) × 40% (deployed at 4 watts) × 51% (percent of active channel time AP transmitting) = 0.052%. Likewise, the percent of 1 watt e.i.r.p. AP transmissions can be calculated as 0.057% (1 watt capable APs) × 40% (deployed at 1 watts) × 58.1% (percent of active channel time AP transmitting) = 0.0132%.

To calculate the percent of directional (point-to-point systems), the study notes that two use cases can be defined. The first is connecting locations medium-to-long-distance apart (longhaul case). The second is to provide backhaul from APs/cell sites to landline networks or last mile to connect user locations that have poor or no service coverage to a point that does (shorthaul case). With an e.i.r.p. of 36 dBm, i.e. with 30 dBm transmitter power and a 6 dBi antenna at either end and assuming free space loss with a 1.1 dB implementation loss, a distance of 800 meters can be covered and still achieve MCS-7[7] transmission rate. Higher gain antennas could also be employed to go even further distances but it is expected that the number of systems will drop off exponentially with distance since need will drop as population density decreases or other shorter link options will be available. These distances would seldom if ever be used for shorthaul purposes and are assumed to be for longhaul. For an e.i.r.p. of 30 dBm, i.e. with 24 dBm transmitter power and a 6 dBi antenna at either end and assuming free space loss with a 1.1 dB implementation loss, a distance of 400 meters can be covered and still achieve MCS-7[8] transmission rate. This is still a long distance for the shorthaul case, which would most typically be no more than a city block away. i.e., 100 to 300 meters[9]. Nevertheless we will assume that 30 dBm e.i.r.p. will be used for all shorthaul deployments.

In order to relate the quantity of longhaul systems to population for simulation purposes, the study notes that a reasonable number could be estimated as 1% of the outdoor AP deployments or (0.057% + 0.255%) × 1% = 0.003%, which defines the 4 watt e.i.r.p. directional allocation.

As for shorthaul systems, we first consider the backhaul requirements. While none of the high density deployments will require any point-to-point backhaul, it was observed from the major technology provider’s network that there was wireless backhaul support of one backhaul system for every 7 APs. Thus the percent of point-to-point backhaul support needed for networks is .0178%, derived from the equation (0.057% + 0.255%) (outdoor APs deployed from 2014 thru 2017) × 40% (percent of outdoor deployments that are medium density) × 14.3 % (1 backhaul for every 7 APs) = .0178%.

Backhaul for outdoor hotspots is likely to be lower since many of these would be installed by landline operators that can backhaul on their own networks or in optimal locations that have a landline connection available. In this case we assume the percentage of hotspot backhaul is .0062%, derived from the equation (0.057% + 0.255%) (Total outdoor APs deployed 2014 thru 2017) × 40% (percent of outdoor APs that are hotspot deployments) × 5% (assumed % of hotspots needing wireless backhaul) = .0062%.

Together 0.024% of total AP deployment are shown to have point-to-point backhaul. To account for random non-backhaul related point-to-point systems, e.g., last mile, we will increase this by 30% to 0.0313%. While there is a significant difference in download and upload data requirements the power in either direction is the same and so whether it is 40% in one direction and 60% in the other it makes no difference when calculating the emissions from an aggregate of systems so no

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[7] Higher order MCS is possible but typically requires larger bandwidth channels that could not be counted on for a point-to-point system.

[8] Higher order MCS is possible but typically requires larger bandwidth channels that could not be counted on for a point-to-point system.

[9] In some suburban outskirts or rural areas there will be some long distance backhaul or last mile instances but these would be few and we would assume would be included in the longhaul case.

adjustment is made. However, there are several bands, both licensed and unlicensed, e.g., 24 and 60 GHz bands in addition to the 2.4 and 5 GHz that are available for point-to-point systems. We therefore assume that only 60% of the point to point systems, 0.0188% will utilize the 2.4 and 5 GHz bands and thus comply with our present density model. This value defines the 1 watt e.i.r.p. directional allocation.

The percentage of outdoor devices were based on years 2014 through 2017. In order to take into account growth, we consider the percentage of aggregate outdoor devices delivered from 2014 thru 2017 versus those delivered from 2014 through 2021. The ratio of the latter to the former is 1.38, so we adjusted all 1 watt and 4 watt omni and directional (point-to-point) percentages upward by this ratio. It may also be noted that the Small Cell Forum forecasts a cumulative number of outdoor small cells deployments between 2015 and 2021 equivalent to 68% of that estimated for RLANs.[10] It is unlikely that more than 50% of these would be involved in RLAN-like transmissions in the 5 150 to 5250 MHz band; e.g., unlicensed or Licensed Assisted Access. Assuming this increase, the study makes a further upward adjustment to the 1 watt and 4 watt distributions of 1.34.

In addition, noting that in Table 1 in this Appendix the average e.i.r.p. value for 4 watt (36 dBm) APs is actually 33.1 dBm and that this value is based on the maximum average conducted power and antenna combination tested across all MCS, channel bandwidths and antenna combinations, this is the value that should be used in computing the aggregate interference and thus is reflected in the e.i.r.p. distribution Table. Since the 1 watt APs were really 4 watt devices with power reduced to meet the antenna mask requirement, no further adjustment is needed.

*Indoor RLAN e.i.r.p. level distribution derivation*

For indoor e.i.r.p. distribution the study considers the three previous outdoor analysis questions, with a few differences, plus one an additional item:

1 When determining the maximum number of devices that are 1 watt or 4 watt capable, antenna mask compliance is not a concern; however, the out-of-band emission PSD limit of –27 dBm/MHz is material. For example, some vendors reduce the e.i.r.p. of Channel 36 to meet the PSD requirement. For the purposes of this analysis, however, this power reduction is not considered.

2 When determining the percent of capable devices that are used to transmit at high power, i.e., 1 or 4 Watts, multiple use cases are considered.

3 When determining the percentage of time high power transmissions occur on an active channel a weighted average across use cases is employed.

4 When considering higher power in a limited space with a limited number of users, the channel activity drops, since the available throughput increases and less transmission time is needed. An adjustment is made to account for this reduction in channel activity.

To address the first item, the same consultant data and the 15.5% study group/global distribution that was employed in the outdoor analysis was analyzed, but, applied to the indoor rather than outdoor counts. This results in the maximum estimate of 1 watt and 4 watt devices capable of operating in the 5 150 to 5 250 MHz band that would be available to be deployed at 86.3% of the total APs in the study area, as of 2017.

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[10] Small Cell Forum Release 10.0 scf, Document 050.10.02, "Small cells market status report", February 2018, Figure 3-1, https://scf.io/en/documents/050_-_Small_cells_market_status_report_February_2018.php.

To address the second item we consider possible high power indoor use cases[11]. There are four main use cases. There are two use cases that partially comprise the Public Access user group: the single AP hotspot case (e.g., cafés, bookstores and retail stores), and the platform case (e.g., trains, planes and buses). The other two use cases comprise the Residential user group: the homespot (residence-based AP featuring two SSIDs, to provide both public and household access), and private (solely for household access).

From the iPass data APs comprising these four main use cases account for 94.77% of all APs in the study area (see Table 3). These are then further divided into 4 watt and 1 watt APs, where 100% of the hotspot and platform use case APs are assumed to be 4 watt, 80% of the Residential use cases are assumed to be 4 watt and 20% 1 watt[12] except for APs associated with DSL broadband access which are assumed to be 100% 1 watt.[13] The result is that 58.2% of all APs in the study area have the potential to employ 4 watt devices and 36.5% 1 watt devices. Other subdivisions of the Residential user group were based on actual cable data and a survey of several sources with three[14,15,16] of particular interest.

TABLE 3

**Indoor use case distribution**

| User Group | Use Case | Broadband Access | AP provider | User Group % | Distribution within user group | % of all APs |
|---|---|---|---|---|---|---|
| **Public Access (4 Watt)** | Single AP HS | Cable/Fiber | Operator | 2.15% | 22.4% | 0.48% |
| | Platform | Cable/Fiber | Operator | | 0.45% | 0.01% |
| **Residential (4 Watt)** | Homespot | Cable/Fiber | Operator | 94.28% | 26.9% | 25.3% |
| | Private | Cable/Fiber | Both | | 17.9% | 16.9% |
| | | Satellite | Operator | | 6.2% | 5.9% |
| | | Cellular Data | Operator | | 10.3% | 9.7% |
| | | | | | **Total** | 58.22% |
| **Residential (1 Watt)** | Private | All of above | Both | 94.28% | 15.3% | 14.43% |
| | | DSL | Client 1W | | 23.5% | 22.1% |
| | | | | | **Total** | 36.5% |

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11 Other indoor use cases are medium and high density deployments that require APs in close proximity to meet capacity demand but in turn require power reduction to prevent co-channel and adjacent channel interference.

12 The percent of 1 watt vs 4 watt APs was based on a survey of the market place.

13 It is assumed that with that the limited broadband speed available over DSL would not justify 4 watt devices.

14 https://arstechnica.com/information-technology/2015/11/comcast-time-warner-cable-get-71-of-new-internet-subscribers/.

15 http://www.ppc-online.com/blog/the-global-broadband-market-2017-is-fixed-broadband-still-growing.

16 https://www.statista.com/statistics/185602/broadband-and-dial-up-internet-connection-usage-in-the-us.

To address the third item, a simple analysis of all identified high power use cases was performed. We note that while channel activity is taken into consideration by application of the activity factor in Table 8, not every transmission during the RLAN's active period is operating at maximum power; i.e., 1 watt or 4 watt e.i.r.p. The transmission time is shared between the AP and its clients, which are not allowed to operate at 4 watts e.i.r.p. The percent of time the AP will be transmitting on an active channel is dependent on the download and upload data requirements and the data rates that can be supported in each direction.

As noted with the outdoor analysis, client devices have an impact on design. For the indoor use cases studied, a distribution of smartphones, tablets and laptops are assumed to follow the 'in home' normalized distribution from the earlier consultant reference.[17] The results of the survey on U.S. device certifications provides the maximum average conducted power, as well as the antenna gain employed for each client device and AP type. These characteristics are presented in Table 4 below and employed in the analysis of each of the use cases.

TABLE 4

**Indoor high power use case device characteristics**

| Type | Phone | Tablet | Laptop | Client Device Avg | Operator Provided AP (4 Watt) | Client Provided AP (4 watt) | Client Provided AP (1 watt) |
|---|---|---|---|---|---|---|---|
| Distribution | 31.6% | 23.0% | 45.4% | | 100% | 72.7% | 27.3% |
| Tx Pwr (dBm) | 19.9 | 19.1 | 19.0 | 19.3 | 27.2 | 28.7 | 22.2 |
| Ant gain (dBi) | -1.5 | 4.8 | 5.1 | 3.8 | 7.6 | 4.8 | 6.4 |
| EIRP (dBm) | 18.4 | 23.9 | 24.1 | 23.1 | 34.8 | 33.5 | 28.6 |

The design objectives and assumptions are provided in Table 5. While coverage can be an issue in some instances, on average, coverage is generally good and reasonably high capacity is the norm. To help estimate the coverage, Recommendation ITU-R P.1238-9 is employed to calculate path loss, as well as floor and wall attenuation. One slight variation is with the homespot use case, in which 50% of the public facing transmission are expected to go to user(s) outdoors and building loss is added in this instance. The other 50% of transmissions are assumed to go to guests indoors. In addition to the path loss, a 1.1 dB implementation loss is also included.

Because high link margins are available, multiple transmission streams can be supported and are included in the throughput calculations. Based on U.S. device certification data, the number of streams available on average are 3 for 4 Watt APs and 2 for 1 Watt APs. It is assumed that the antennas are available in both directions; e.g., 3×3 or 2×2 MIMO configurations. To minimize further complexity, only 20 MHz channels were included, although additional efficiencies would increase the available throughput. In determining the throughput, 31% overhead was assumed to account for TCP and multiuser MAC. No degradation due to interference was assumed.

[17] See Statista data, https://www.statista.com/statistics/183648/average-size-of-households-in-the-us/.

To determine the residential transmission rate and down/up ratio required, a number of broadband access studies to be reviewed. Four of these were found most useful. [18,19,20,21] The total per household traffic (down + up) requirement observed for 2017, per household, ranged from 0.5 Mbps to 5.42 Mbps and the larger value of 5.42 Mbps was assumed for the analysis. The down/up ratio projected for 2021 ranged from 4.55 Mbps to 8.83 Mbps. An average of 6.31 Mbps. was assumed. Four observations are made with respect to the values assumed.

1 Not all broadband capable devices access Internet content through the RLAN. For example, television sets, which drive a large part of the demand, may be directly connected to an Ethernet port.

2 Total traffic will continue to grow but so will RLAN transmission capability so 2017 values are appropriate to use.

3 Down/up ratios will continue to grow, mostly due to video streaming. And, while technology is assumed to meet the overall demand, the usage of the TDD channel will change so the 2021 ratio is more appropriate.

4 The homespot APs are used to provide for both public and household demand. For this subcase the homespot, public facing demand was calculated by subtracting all other users (Corporate, Public Access and Residential) engaged during the busy hour and applying the Public Access 83% market factor and 50% busy hour factor to the remaining population. Dividing by the number of homespot APs yields 0.68 users per AP, each provided with a transmission rate of 1.0 Mbps.

For the single AP hotspot use case throughput we assume the average hotspot location will have 10 people × 83% market factor × 50% busy hour factor × 1 Mbps throughput per user.

For the platform use case throughput we assume the average AP in a bus, plane or train car covers 100 seats × 80% fill 83% market factor × 50% busy hour factor × 0.5 Mbps per user.

For both the hotspot and platform use cases we assume a down/up ratio of 4.18, the same as for the outdoor hotspot use case.

The throughput is checked to be sure the transmission requirements in both directions is achieved. Downstream and upstream time allocations were then calculated to meet the down/up objective and presented in Table 6, along with a weighted average for each 4 Watt and 1 Watt cases.

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[18] Adtran, "Defining Broadband Speeds: Deriving Required Capacity in Access Networks", An ADTRAN White Paper, 2009.

[19] Michael Kennedy, "ACG Research, Forecast of Residential Fixed Broadband and Subscription Video Requirements", pp. 9, Figure 8, ACG Research, Dec 4, 2014, http://acgcc.com/wp-content/uploads/2014/12/Forecast-of-Residential-Fixed-Broadband-Requirements-2014.pdf.

[20] Michael J. Emmendorfer and Thomas J. Cloonan, "Nielsen's Law vs. Nielsen TV Viewership for network capacity planning", ARRIS, 2014, https://www.nctatechnicalpapers.com/Paper/2014/2014-nielsen-s-law-vs-nielsen-tv-viewership-for-network-capacity-planning.

[21] 1H 2014 Global Internet Phenomena Report, Sandvine, https://www.sandvine.com/hubfs/downloads/archive/2014-1h-global-internet-phenomena-report.pdf.

TABLE 5

**Indoor design criteria**

| User Group | Use Case | Broadband Access | Link Length (m) | Floors/walls penetrated | Path Loss (dB) | Num Streams Supported | Site Throughput requirement (Mbps) | DN/UP objective |
|---|---|---|---|---|---|---|---|---|
| Public Access (4 Watt) | Single AP HS | Cable/Fiber | 4 | 1 wall | 70.8 | 3 | 4.1 | 4.18 |
| | Platform | Cable/Fiber | 4 | None | 63.8 | 3 | 16.6 | 4.18 |
| Residential (4 Watt) | Homespot | Cable/Fiber | 10 | 1 floor + % of 1 OD wall | 86.8 | 3 | 6.1 | 6.31 |
| | Private | Cable/Fiber | 10 | 1 floor | 85.6 | 3 | 5.4 | 6.31 |
| | | Satellite | 10 | 1 floor | 85.6 | 3 | 5.4 | 6.31 |
| | | Cellular Data | 10 | 1 floor | 85.6 | 3 | 5.4 | 6.31 |
| Residential (1 Watt) | Private | All of above | 10 | 1 floor | 85.6 | 2 | 5.4 | 6.31 |
| | | DSL | 10 | 1 floor | 85.6 | 2 | 5.4 | 6.31 |

With respect to the fourth item, it was previously noted that the use cases comprising this indoor analysis involve the use of relatively high transmitter power in a limited space with a relatively small number of users. This results in a reduction in channel activity corresponding to the increase in throughput available to each user and reduces the transmission time needed. Rather than adjusting the activity factor, which would also impact non-effected users, an adjustment is made to the 4 and 1 Watt indoor e.i.r.p. distributions to account for this reduction in channel activity.

Table 6 provides the results of the activity adjustment calculations along with weighted averaging of both AP transmit channel time distribution and AP e.i.r.p. The activity adjustment is determined first by estimating the actual channel activity as the required throughput divided by the available throughput[22]. Once the estimated activity is determined it is compared to the 15% activity factor assumed for the Public Access cases or 9.5% assumed for the Residential cases to determine the amount of discount that should be applied.

TABLE 6

**Some e.i.r.p. distribution factors**

| User Group | Use Case | Broadband Access | Normalized % for wtg | Required throughput (Mbps) | Supported throughput DN (Mbps) | Actual Activity | Adjustment as % relative to activity factor | Channel time allocation % DN | Eirp by type (dBm) |
|---|---|---|---|---|---|---|---|---|---|
| Public Access (4 Watt) | Single AP HS | Cable/Fiber | 0.82% | 4.1 | 163.6 | 2.5% | 16.7% | 73.6% | 34.8 |
| | Platform | Cable/Fiber | 0.02% | 16.6 | 163.6 | 10.1% | 67.7% | 73.6% | 34.8 |
| Residential (4 Watt) | Homespot | Cable/Fiber | 43.50% | 6.1 | 124.0 | 4.9% | 51.4% | 71.6% | 34.8 |
| | Private | Cable/Fiber | 29.00% | 5.4 | 124.0 | 4.4% | 46.0% | 71.6% | 33.5 |
| | | Satellite | 10.06% | 5.4 | 124.0 | 4.4% | 46.0% | 71.6% | 34.8 |
| | | Cellular Data | 16.61% | 5.4 | 124.0 | 4.4% | 46.0% | 71.6% | 34.8 |
| | | | | | | Wtg Avg | 48.1% | 71.7% | 34.4 |
| Residential (1 Watt) | Private | All of above | 39.49% | 5.4 | 91.3 | 5.9% | 62.5% | 79.1% | 28.6 |
| | | DSL | 60.51% | 5.4 | 91.3 | 5.9% | 62.5% | 79.1% | 28.6 |
| | | | | | | Wtg Avg | 62.5% | 79.1% | 28.6 |

Incorporating the findings from the four analysis items considered above, the study concludes that the percent of 4 and 1 Watt e.i.r.p. AP transmissions can be calculated as:

(new post rule capable APs as a % of total APs) × (% deployed at 4 or 1 Watts) × (percent of active channel time the AP transmitting) × (the discount from the activity factors used in the study).

[22] The available throughput is the available throughput down and up multiplied by their respective channel time allocations and added together.

The results for both 4 Watt and 1 Watt distributions for indoor devices are shown in Table 7 and were based on years 2014 through 2017.

In order to take into account any change in the percentage of indoor devices out to 2021, we consider the percentage of aggregate indoor devices delivered from 2014 thru 2017 versus those delivered from 2014 through 2021. The ratio of the latter to the former is 0.74, so all 1 Watt and 4 Watt percentages are adjusted downward by this ratio. In addition, as previously discussed, the Small Cell Forum forecasts a cumulative number of small cell deployments between 2015 and 2021. The number of indoor cells forecast is equivalent to 2.9% of that estimated for RLANs. It is unlikely that more than 50% of these would be involved in RLAN-like transmissions in the 5 150 to 5 250 MHz band; e.g., unlicensed or License Assisted Access. Assuming this increase, we make an upward adjustment to the 1 watt and 4 Watt distributions of 1.014. These adjustments are also included in Table 7.

In addition, noting that in Table 6 the weighted average e.i.r.p. value for 4 Watt (36 dBm) APs is actually 34.7 dBm and for 1 Watt (30 dBm) APs is actually 28.6 dBm, and that these values are based on the maximum average conducted power and antenna combination tested across all MCS, channel bandwidths, and antenna combinations, these are the values that should be used in computing the aggregate interference and are thus are reflected in the e.i.r.p. distribution table.

TABLE 7

**Calculation of e.i.r.p. distribution percent of indoor devices**

| Factors | 4 watt | 1 watt |
|---|---|---|
| % of new devices | 86.3% | 86.3% |
| 4/1 watt % of total APs | 58.2% | 36.5% |
| Active chan time allocation | 71.7% | 79.1% |
| Activity factor discount | 48.1% | 62.5% |
| **e.i.r.p. distribution** | 17.3% | 15.6% |
| Time frame adjustment | 0.74 | 0.74 |
| Contribution of small cells | 1.014 | 1.014 |
| **Adj e.i.r.p. distribution** | 13.0% | 11.7% |

Table 8 provides the e.i.r.p. level distributions resulting from the above analysis and updates Table 1b of Document 5A/650 (Annex 21), *Report ITU-T M.[RLAN REQ-PAR]*.

TABLE 8

**RLAN e.i.r.p level distributions**

| Type | 4 W (directional) | 4 W (omni) | 1 W (directional) | 1 W (omni) | 200 mW (omni) | 80 mW (omni) | 50 mW (omni) | 25 mW (omni) | Total % | Wgt Avg EIRP |
|---|---|---|---|---|---|---|---|---|---|---|
| Indoor | 34.7 dBm | 34.7 dBm | 28.6 dBm | 28.6 dBm | 23 dBm | 19 dBm | 17 dBm | 14 dBm | | |
| E.I.R.P.s | 2965 mW | 2965 mW | 724 mW | 724 mW | 200 mW | 80 mW | 50 mW | 25 mW | | |
| Indoor % | 0.0% | 13.0% | 0.0% | 11.7% | 14% | 19.82% | 10.99% | 28.56% | 98.00% | 27.3 dBm |
| Outdoor | 33.1 dBm | 33.1 dBm | 30 dBm | 30 dBm | 23 dBm | 19 dBm | 17 dBm | 14 dBm | | |
| E.I.R.P.s | 2051 mW | 2051 mW | 1000 mW | 1000 mW | 200 mW | 80 mW | 50 mW | 25 mW | | |
| Outdoor % | 0.006% | 0.096% | 0.035% | 0.024% | 0.35% | 0.50% | 0.28% | 0.72% | 2.00% | 23.1 dBm |